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Part, I

Part i

Historical Sketch of the Origin and Progress of the Ganges Canal

Chapter i

Preliminary Period under the Directorship of Lieut. Colonel P.T. Cautley From 1839 to 1845

The direction of the drainage on the Southern Slopes of the Himalayas throughout the N.W. Provinces of Upper India lying to the North west; the character of the Rivers which constitute this drainage; and the topographical features of the Country through which it passes; point out by unmistakeable signs, a region designated by Nature as a great field for artificial Irrigation. These Rivers after their debouche from the mountains enter upon a Champaign Country with a rapidly decreasing slope, and from the N.W. parallel direction which they assume in their passage to the Indus on one side, and to the Ganges on the other, divide the N.W. country into sections of a larger or smaller width, all of which both in Soil and declivity of Surface possess in themselves every requisite

for

for Irrigation. The steep slopes that exist at the immediate debouche from the mountains enable the Engineer by a proper adaptation of levels in his artificial Channels, to obtain a command of water, which places the whole Country under his control; the benefits in fact that he is able to confer upon it by means of Irrigation, are limited ~~by~~ the volumes of water which are ~~placed~~ at his disposal, and his greatest, it may be said his only difficulties are in the neighborhood of these steep slopes, and in their connection with Mountain Torents. From the above description it will be evident that a Canal whose Head supply is derived from the higher levels of these Rivers, and whose course is carried parallel to them, must inevitably act as a ~~supply~~ medium for Irrigation; this plain fact is appreciated by every Villager who resides in the ~~neighborhood~~ vicinity of these Rivers, and who although he ~~has~~ may not have the means, in the possession of land, of turning it to account in Irrigation, yet adopts the principle in ~~making~~ designing Cuts to turn his Corn Mills, or in ~~making~~ establishing Dams for the application of his fishing apparatus. On a larger Scale this same fact has been taken advantage of by our Patan and Moghul predecessors not only on the Jumna, but on the Rivers in Rohilkund and in the Punjab; On the Jumna especially the Canals on the East

and

and the West of that River, which within the last thirty years have been restored by the British Govern-ment, are vestiges of its early appr-eciation; the Hasli Canal from the Ravi in the Punjab is of the same character; while Rohilkund and the Countries bordering on the Indus throughout their length and breadth offer a variety of Specimens of Canals of more humble pretensions, but proving in every case that the method of obtaining Irrigation was perfectly understood. With so many examples before us, no great exertion of intellect was required to arrive at the conclusion that the System might be generalized; with a Map before us, it was fair to infer, that if Canals had been so easily supplied from the Jumna, under similar circumstances, similar Canals might be taken from the Jhelum, from the Chenab, from the Ravi, from the Sutlej, from the Ganges, from the Ramgunga, or from any other of the Rivers that after leaving the mountains pass over a Country, possessing in its contour every qualification for enabling the Engineer to make the best possible use of the water that could be distributed over it.—

It was under these well known characteristics of Surface, and with the example of the Jumna Canals before us, that the idea of taking a line from the

Ganges

Ganges originated. There were na-
=tural difficulties existing on both
sides of this River at, and im=
=mediately below the point where
it leaves the mountains, that had
notoriously injured its reputation
as a source of Supply for a Canal;
but so little was known of the *
detail of these difficulties, or ~~to~~ the
~~what~~ extent, to which the surface of the
Country was affected by them,
that ~~on the branch denominated~~
~~the Boodhi Gunga, from the cir=~~
~~=cumstance of its relative posi=~~
~~=tion to the Ganges being similar~~
~~to that of the Boodhi Jumna from~~
~~which the Eastern Jumna Canal~~
~~supply is taken / with the main~~
stream of the Jumna, was considered
~~as equally appropriate position~~
~~for the Head of the Ganges Canal~~.
It was from a point near the vil=
=lage of Badshahpoor marked A
in Diagram I, that the first line
of levels was taken; the extraordinary
elevation of the country at D, ~~of the~~
~~region~~ from whence the high land
of the Doab commences, was then
not known by those interested in
Irrigation. At the point where the
line of levels from the boundary of the high land A crossed ~~D~~, the
rise of country ~~from the low to the~~
~~high land~~ was equal to 83.225 feet;
the possibility, of the case, of using the Boodhi
Gunga, ~~the first~~, as a Head for a
Canal was totally out of the *
question, but the same course of
reasoning which had led to the
adoption of the Boodhi Gunga in
the

in consequence of the similarity of connection between the Boodhi Gunga & Boodhi Jumna, & the main Rivers of which they were respectively ancient branches, a hope was entertained that the former would persist a site for the head works of the Ganges Canal equally appropriate & effective with those supplied by the latter for the Head works of the Eastern Jumna Canal.

the first instance, further led to that of a point situated on the main River at higher levels; as it was clear that by proceeding higher, and ~~placing the cost out of long irrigation expense out of the question~~, the certainty of discovering a line upon which a Canal might be traced was ~~undoubted~~ indubitable? inevitable?.

2. Before entering upon the narrative of the rise and progress of the works on the Ganges Canal, a few words on former projects for the irrigation of the Districts which ~~were to be placed~~ under its influence may be appropriate; These, so far as I am aware are ~~only two in number~~ limited to ~~as far as I am aware of two~~: the first, a Muhummud Aboo Khan's Canal which appertains to a period prior to the accession of the British - the Second a project of ~~Captain~~ Debude's, of the Bengal Engineers, submitted to Government in 1827.-

3. The Canal of Muhummud Aboo Khan, the remains of which still exist in the neighborhood, and to the North North West of Meerut, consisted of a Cut made from the west Kalli Nuddi near the village of Ramsoor, to the head of a Small tributary of the East Kalli Nuddi, called the Khodara Nulla. ~~The source of~~ which ~~tributary~~ rises near the village of Deorala; the length of this Cut did not exceed 12½ Miles, and its dimensions judging from the existing hollow could not have exceeded 15 feet in width; the water after reaching Deorala must have passed down the Khodara Nulla ~~tributary~~ to the Town of Meerut

in

in the neighborhood of which there are many groves and gardens, and it is supposed that it was for the purpose of supplying water to these ~~groves and gardens~~ that the Canal was originally projected; there is no tradition known of its existence as a running ~~line of water~~ stream, although there is no reason to doubt that for a season at least ~~this was the case~~ it was so. The Canal ~~Nestaw~~ was evidently one of those which from the circumstances under ~~which it derived~~ affording its supply, and from the total absence of all Masonry works, could not have been classed under the head of permanent works for Irrigation.- The west Kalli Nuddi at the village of Ramporr, although ~~a stream~~ a perennial stream, is one of those lines of drainage which during the periodical rains is subject to very great floods; the River meanders thro'gh a valley of considerable extent, and during the dry months is 30 feet below the level of the country, or below that land over which Muhammud Abor Khan's Canal was ~~excavated~~ carried; the Canal was merely excavated to a few feet in depth, and water was supplied ~~to this Channel~~ from a lake formed by throwing an Embankment across the bed of the west Kalli Nuddi.. The flooding of the valley by this retention or damming up its waters, must have done extraordinary damage to the properties within its limits ~~under its influence~~;

the

the amount of money and labor expended on an Embankment of proportions sufficient to gain the Engineers object must have been very great; and the necessity for an Annual reconstruction of a work which was ~~necessarily~~ inevitably destroyed during the rain floods, and the certainty that water could only have reached the mouth of the Canal during the dry months of the Year, are facts which reasonably lead us to conclude that no great benefit was ever derived by the cultivators on the high lands in its vicinity. The line of the present Ganges Canal Channel crosses the remains of Aboo's Canal (as it is now called) at an Angle of 50° near the Village of Jowalagurh and by a singular perversion of purpose, that portion of it which approaches the Canal from the West Kalli Nudde at Furreedpoor is now converted into an Escape, for throwing the waste water from the Canal into the Valley of the River. The plan above described as carried into effect by Aboo Khan is an illustration of Canal designing, which is by no means uncommon in this part of India: it possibly originated partly in the inability of the Owners of the site upon which the bund was erected, to take possession of land at a higher level of the Rivers course, and partly from the apparent magnificence of a design which in converting dry land into

^ Muhammed Aboo appears to have made two attempts at obtaining water from the West Kalli Nudde viz: that at Ranpoor Lepe described, and a lower one from the village of Furreedpoor: traces of both these cuts which joined at a point near Jowalagurh were distinctly discernible at the date of our operations.

into a Lake, realized in the eyes
of the multitude the acts of the
Jinns or Genii of Eastern Fable.-
Over the Kirsunni or Kristna River
which runs Eastward and paral-
-lel to the west Kalli Nudii, and
close by the Towns of Jullalabad
and Thannabhown, a similar
work appears to have been execu-
-ted during the short period of
Gholam Kadir's Government, the
Bund thrown over the River at this
point was of moderate extent in
comparison with that at Rampoor,
but its purposes were the same.-
Bunds of this sort were by no
means uncommon in the earlier
history of these districts, and at
the present day, every River in
the Tract of Country between the
Jumna and Ganges, is interrupted
in the ~~lastly~~ upper parts of its course by
Embankments more or less extensive
for the purpose of collecting a sup-
-ply of water for Irrigation.- In
the Delhi and adjoining Districts
as well as in the Districts further
west, Irrigation from Reservoirs of
the above description is extensively
used.- Captain
4. ~~Hutt~~ Debude's project
to which I have refered as the
second instance recorded of an
attempt to supply the means of
Irrigation to the lands on the
Right of the Ganges, was in fact
a mere enlargement of the scheme
originated by Mahummed Aboo
Khan, in so far that the plan
of damming up the west Kalli

Nudii

+ note

Nuddi and raising the water until it was able to afford a supply to a Channel excavated on high levels, was resorted to; ~~Major~~ Captain Debude in fact adopted the Site of Mahummud Abbo Khan's Embankment on the west Kalli Nuddi as the position of the Head of his Canal, and although the works for irrigation which were projected by him were calculated to be of more extended benefit, they were as all our Canal undertakings had been up to that period, a mere attempt to restore, and in restoring to improve upon, the acts of our Predecessors.—

4 I have before explained that Mahummed Abbo Khan's Canal was a mere Cut for the apparent purposes of giving water to the Town of Meerut and the Gardens in its neighborhood; ~~Major~~ Captain Debude's idea was to extend the benefits of the introduction of water on the high levels, by carry-ing a Canal to the South through the Meerut, Bolundshuhur, and the Northern portion of the Aligurh Districts: the possibility of obtain-ing a supply for this purpose from the Ganges River under the difficulties that were supposed to exist, did not enter into his cal-culations, and the whole bent of his mind was directed to devising the best and most economical method of ~~existing to his service~~ turning to profitable account the ~~whole~~ available supply ~~to be furnished by derived from~~ the perennial Streams connected with the west Kalli Nuddi

and

and its Tributaries.—

F. The Bindura River which in character is similar in every respect to the West Kalli Nuddi, runs parallel to, and joins the latter River on its Right bank at a point about 10 Miles below the Village of Rampoor, or the Site of Muhummed Aboo Khan's Em-=bankment. The supply of water in the Bindura River is continuous during the year, and, as is the case with the West Kalli Nuddi, increases during the rainy months to a very considerable volume. It was ~~Major~~ Captain Debude's intention to throw Embank-=ments with Masonry Sluices over both these Rivers; to create by ~~these~~ such means two gigantic reservoirs connected by an excavated Cut, and by these works to raise the level of the water to a sufficient height, to enable him to pass it off at a Canal Head which was situated at Rampoor.—

E. It would be out of place here to enter into a detail of a project which, although it was never carried out, may be con-=sidered as the germ of future operations for the economical ap-=plication of waters now allowed to run to waste; it will be sufficient to state that ~~Major~~ Captain Debude's scheme involved the construction of two very extensive Masonry Dams with their Embankments over the Rivers above described, the Sill of that on the Bindura being 15 feet, and

that

that on the West Kalli Nudi, 25 feet above the beds of their respective Rivers; it involved, moreover, a Sacrifice of a considerable tract of very valuable land which would have been inundated on the formation of the Reservoirs, ~~There was reason however to Doubt and the Question of~~ whether during the Rainy Months, or ~~during~~ for that period when irrigation is especially required for Sugar Cane and Rice, the regularity of supply could have been insured, & whether, even during the dry months, the reservoirs, being subject ~~as they were~~ to ~~the Contingencies of~~ diminution of volume from the effects of evaporation and absorption, could keep up a supply sufficient for the purposes of irrigation. ~~was that which~~ and in all probability uncertainty on these points led to the Sacrifice of the project. The plans and papers were Submitted in great detail to Lord William Bentinck (1831) who was then Governor General, with an Estimate amounting to & about Three Lakhs of Rupees.

~~C~~ The difficulty as well as danger of interfering with the courses of Rivers liable as the Vinduv and West Kalli Nudii are to floods of the most violent description during the rainy months, were by no means unappreciated by Capt^n Delvude, but the times during which he carried on his labors, were not those when the advantages of irrigation

irrigation were understood and recognized as they were a few years afterwards; Captain Debude's means were limited, not only by the in=structions under which he acted, but by the certainty that Estimates to a large amount would not be viewed by the Government with the slightest satisfaction; whatever, therefore, may have been Capt.n Debude's views as to the feasibility of obtaining a supply of water from the Ganges on the principles that had already been adopted on the Jumna River, no reference is made to them in any of the papers that have come under my cognizance, and his ultimate removal to a superior appointment in Calcutta, which took him entirely from the scene of his early Engineering enquiries in the North West Provinces, gave a new direction to his thoughts, and introduced him to new fields ~~in which~~ wherein his talents were as pro=fitably exerted as they had been elsewhere.—

E.— As time advanced, and the results of the Jumna Canals had proved to the Government that the money which had been laid out on these works had been most profitably expended, that inde=pendently of paying off their own expenses annually, they were both directly and indirectly increasing the Land Revenue, improving the resources of the country, and greatly benefitting

the

the Community; of Irrigation views, on a more extended scale ~~to the regard to Irri-gation~~ were freely advanced. ~~The District of~~ Rohilkund which had from time immemorial been the field of very extensive irrigation, disarranged it is true by the anarchy that had prevailed previously to its settlement as a Regulation Province, but still containing within itself all the vestiges of its ancient Canals, water courses and Dams, was one of the first Localities ~~Districts~~ that came under the notice of Government: a series of papers illustrative of ~~in connection with~~ this Irrigation was submitted to Colonel Colvin, the Superintendent of Canals at that time, and subsequent Inquiries led to the deputation of that Officer to report upon certain projects for the immediate restoration of some of the Old lines. Colonel Colvins report and the favorable opinion ~~that~~ he expressed, of the extraordinary capabilities of the District led to the appointment of an Engineer Officer to Superintend the execution of a line of Canal near the Town of Nugeena; the completion of this work, and afterwards the appointment of Captain William Jones of the Bengal Engineers to carry out the intentions of Government in extending the means of Irrigation throughout the Province, led to the ~~establishment of Rohilkund Irrigation Branch~~ ~~placed on~~ a permanent system ~~of~~ under an Officer entitled "Superintendent of Canals and Embankments

" in

"in Rohilkund" Captain Jones who ~~still continues to~~ held this appointment up to the year 1854, is the Author of a variety of reports on the subject of Irrigation in the province.—

II. In 1836, Colonel Colvin left India, having devoted a long period of his life to the Canals in these provinces, and having left a Spirit of emulation amongst his Successors, the result of which has been favorable in no small degree to the advancement of those objects to which so much of his time had been devoted.—

~~12~~. In 1837, the Dehra Doon or Valley between the Jumna and Ganges, ~~and~~ lying north of the Saharunpoor District from which it is separated by a low line of mountains called the Sewaliks, became the field of Enquiry for Irrigation purposes; the Valley itself was intersected by running Rivers, and the Himalayas which bounded its Northern front Supplied from numerous perennial streams of ~~the~~ greater or less ~~Extent~~ volume, ample means for providing irrigation to the high lands ~~which~~ forming ~~constitute~~ the Northern part of the Valley. The examination of ~~this~~ a field thus prolific in its means for irrigation, has led to the execution of numerous works; the Beejapoor, Rajpoor, and Kutta Puttur Canals have been already executed; two other lines, which come under the designation of the Kalunga and Sunsadhara

Canals

Canals, have been delayed in exe=
=cution merely from want of
Executive Superintendence: and
numerous unexamined Streams
~~which as~~ now lost in the Ra=
=vines and Forests which skirt
the base of the Himalayas, are
in all probability as capable
of being turned to useful account
as those which have been already
worked upon. —

~~To~~ About the same period
that the Doon Irrigation was
brought to the notice of the
Government, Major Baker,
the Superintendent of the Delhi
Canals was occupying himself
~~in~~ many useful enquiries as to
the means for supplying irriga
=tion to the country lying between
the Jumna and the Sutlej Rivers;
the results of these enquiries (as embodied in a series of reports and papers) were
published by the Government
of the North Western Provinces
~~in a series of reports and papers~~.
The Sugger ~~a River~~ which leaves
the Hills ~~at~~ the Eastern extremity
of the Pinjore Valley, was the
only line of perennial River
that ~~last up to~~ prior to the period of
Major Baker's enquiries had been tu=
=rn up as a supply for Irri=
=gation; ~~he caused of~~ its being
brought under the consideration
of Government at all ~~was~~, I
believe, due to certain disputed
rights of water claimed by an
independent Sikh chief (the
Puttiala Raja) through whose
territories a portion of its course

runs,

runs; ~~in an endeavour to settle the disputed rights~~, Engineer Officers had been deputed to establish works for regulating ~~the~~ ~~distribution~~, and ~~to~~ equalizing the ~~applicable supply~~ ~~benefits to the neighbouring Talookas~~: the means of Irrigation ~~however, which were~~ offered by the Cugger ^however were comparatively small, and were confined entirely to the establishment of earthen Dams at fixed intervals for the formation of Reservoirs from whence the Irrigators drew their water: the value of the Cugger as an Irrigating ~~Reservoir~~ stream was in fact confined to a narrow tract on ~~each~~ edge of the River.- Major Baker's ~~object therefore, was to look to some more comprehensive method of Irrigation, derived from a supply that would not fail, and which would benefit the distant lands lying to the South and West of Ferozpoor, as well as those which situated on the right or North of the Delhi Canal, were from their elevated position incapable of enjoying its benefits.~~ -

The Sutlej River on its approach to the plains at Roopur takes a considerable turn to the west regaining its Eastern direction ~~by a~~ sharp ^abrupt bend; the course of the River at this point forming a long loop, the neck of which is not more than 7 Miles in width.- It ^to a point was above this loop ~~with all the advantages of slope gained by the course of the River~~ as giving evident advantages of slope that

Baker was accordingly led on to the consideration of some more Comprehensive scheme, embracing not only certainty of the supply but extension of the area to be irrigated so as to include the distant lands to the South and West of Ferozepoor, together with those on the right bank or to the North of the Delhi Canals, the levels of which are too high to admit of there being watered from that line.

that Major Baker's attention was first directed as promising an appropriate site in the head of a Canal; to this idea however the mountain ridge which leads to the Deviation of the River from its direct course opposed an insurmountable barrier; the highest accessible point therefore was selected by Major Baker in the commencement of a line ~~that Major Baker fixed upon a point for the Head of a Canal the course of~~ which was to ~~extend~~ pass centrically through the country bounded by the Sutlej and the Jumna. The results of the Survey shewed the feasibility of a project which would provide Irriga-tion to an immense extent of country, the more western parts of which ~~are at present totally unirrigable. totally without the means of Irrigation~~ even from wells, and ~~where the want~~ at the same time would supply water for Domestic uses in regions now ~~of water for drinking purposes, and reduced to deserts from the total want of it reduced whole regions to a state of desert~~.

Major Baker having satisfied himself ~~with~~ the fact that the Sutlej might be ~~converted into a supply~~ made use of for Irrigation, and having carefully examined the Country lying be-tween Loodiana and Kurnal; submitted his views to the Govern-ment. - At this time a great portion of the land over which the projected Canal would have taken its course was in the hands of Independent Sikh Chiefs and others who recognized no further control by the British Govern-ment than that offered by treaty for their protection: no regular plans and Estimates therefore were submitted to the Government, and the whole Question, interesting as it was at the time, was allowed to drop. - Laying aside the reasons for adopting this course, which I have no doubt were in every way sufficient, but at the same time, looking ~~as I do~~ to the extraordinary benefits that the Country would have derived from the introduction of water, and the con-se-

=sequent establishment of Villages and Agriculture, on a large ~~surface of Country~~ area which is now a wilder=ness; knowing, moreover, the singular=ly fertile nature of the soil at those points where the blessings of water are ~~distributed~~ felt even in ~~its~~ their most ~~parsimonious sense~~ limited extent; looking to the predatory life of the scattered population now existing, and con=templating the certain change to that of Agriculture with all its concomi=tant ~~blessings~~ advantages; the causes that led to the abandonment of Major Baker's project may I think be regretted, and we may hope that with the satisfactory data he has provided, and with the daily increasing Interest that is arising in the ex=tension of Irrigation, the subject of the Sutlej Canal may ~~be~~ ere long be resumed with full vigor.

~~The above gives~~ I have now completed a rapid outline of the different projects ~~that have come under consideration~~ for Canals ~~making~~ in the North West provinces, the Sur=veys of which had been conducted at the same time with those ~~for the Establishment~~ of a line of Canal for the irrigation of the Country between the Jumna and the Ganges, or of that line which ~~is~~ especially the sub=ject of the present paper.

I have before mentioned that the only attempt ~~that~~ which had been made in our time for the irrigation of the land lying on the right of the Ganges River,

River, ~~were those in~~ which was when Captain Debude ~~had~~ proposed to make use of the waters of the Hindun and west Kalli Nuddies, and by establishing Dams over their courses to obtain ~~a the means of supply for Irrigating~~ for the Meerut Bolundshuhur and Aligurh Districts the site of ~~Captain Debude's~~ the proposed works being ~~that of~~ on an ancient Canal ~~supposed to have been dug early in the 18th Century by a Native Chief by name Muhammed Abdoo Khan~~

bearing the name of Muhammad Abdo Khan, a native chief by whom it was supposed to have been dug early in the 18th Century.

Captain Debude's enquiries established the fact, that the united volumes of the above mentioned two Rivers would not during the dry months provide a supply that would last longer than 180 days and that during the rainy months the works on the Rivers themselves would be subjected to the most extreme flood action:- ~~From~~ To these sources, therefore, it was hopeless to look for ~~a supply sufficient to meet~~ the means of meeting the demands of any comprehensive scheme for irrigation The Ganges River alone could, consequently be ~~looked to~~ depended on: Colonel John Colvin C.B. at that time Superintendent General of Canals, was satisfied that an examination of the River above and below Hurdwar would prove its efficiency for the purposes required; ~~both~~ Colonel Colvin's views and my own ~~views~~ coincided on the adviseability of making early enquiries, and subjecting that part of the Khadir or low land lying between Hurdwar and the Head of the East Kalli Nuddi to careful survey ~~& demarcation~~

~~Examination~~ careful survey; the impracticable ~ lining out of this part of the Country, especially the depressed tract of land above alluded to, and the abrupt ~ transition from high to low ~~land~~ rocks in the neighborhood of Doonassi, Noornugger and Sookurtal, were certainly features by no means favorable to success, but it was de-=termined to settle the question at the earliest opportunity possible-

~~At the end of 1836~~ at the end of 1836 Colonel Colvin left India giving over charge of his duties as Superintendent ~ General of Canals to me; and it was in November of that Year that the first series of levels was taken; The Banguna, an Old Branch of the Ganges River, is ~~situated with reference to~~ connected with the Parent Stream, in the same way that the Boodhi Gumna is ~~situated with reference to~~ with the Gumna River. The Head of the Boodhi Gumna is the Head of the Eastern Gumna Canal; it was supposed therefore, that the Banguna might ~~play the same part in Connection with~~ do equally good service at the head of a Canal from the Ganges.- The village of Baulshahpoor which is close to the Banguna was ~~the~~ ~~terminus to~~ selected as a favorable point from whence to commence a series of levels ~~from~~, and the most desirable ~~point to be discovered~~ question to decide, was the difference of level between the water at that point, and the high land near the village of Rampoor ~~which~~ ~~was~~ the site of Captain Debude's Canal Head after he had raised the water by means of ~~Bunds~~ Dams to a height of

of 30 feet from the West bank of the Kalli Nudi.- The results as will be seen from Diagram I were very unsatisfactory, and shewed that the point which had been taken up on the Banganga was totally unfitted for the site of a Head of supply So to try, therefore, a point higher up on the line of the Ganges, was the ~~second~~ method of overcoming the difficulty which offered itself, and it appeared that by taking a circuitous route the ~~apparently~~ impracticable line of country might be avoided.- Colonel Colvin with whom I was in correspondence on the subject was sanguine that success would ultimately attend an enquiry having for its object the examination of the Country lying between the Sewaliks and the high land of the Doab; it ~~appeared~~ seemed to me however that under such difficulties it was more than probable that the ~~expenses attending upon a~~ cost of a Canal would be ~~of~~ too great ~~a magnitude~~ to warrant the undertaking of the work, and it was not until some time afterwards when I had made myself acquainted with the features of ~~this~~ the tract above referred to ~~of country~~, and had examined the data which I had obtained in my Baolshahpoor levels, ~~and compared~~ comparing them with those of the Eastern Jumna Canal and the known Barometrical heights which connected the whole, that I was able to form a proper Estimate of the ~~probability or not~~ practicability of such a work ~~being practicable~~:- At the time, however, my occupations were of a nature that prevented me from continuing the Enquiry, and the question remained temporarily at rest. ~~for the present~~.-

At this period the Appointment of Superintendent of Canals in which I had been acting since Col Colvin's departure for England, was abolished and I returned to my Duties as Superintendent of the Eastern Jumna Canal & its Dependencies

The calamitous events of the Year 1837-1838- and the extent of human

human misery ~~brought on~~ then caused by the ~~xxx~~ utter failure of the crops in the Central pro=vinces, especially in the lower Dis=tricts of the Doab, leading to famine in its most aggravated shape, and to misery such as is unknown in Civilized Europe, are not even at the present day forgotten by those who at that time were resident in Upper India. The exertions of the European community in alleviating the suf=ferings of a starving population were carried on with true Anglo Saxon energy, and the sacrifice of a Million sterling in Revenue, either in remission or in distributing food, was a guar=antee of the interest that the Govern=ment felt in this frightful calamity

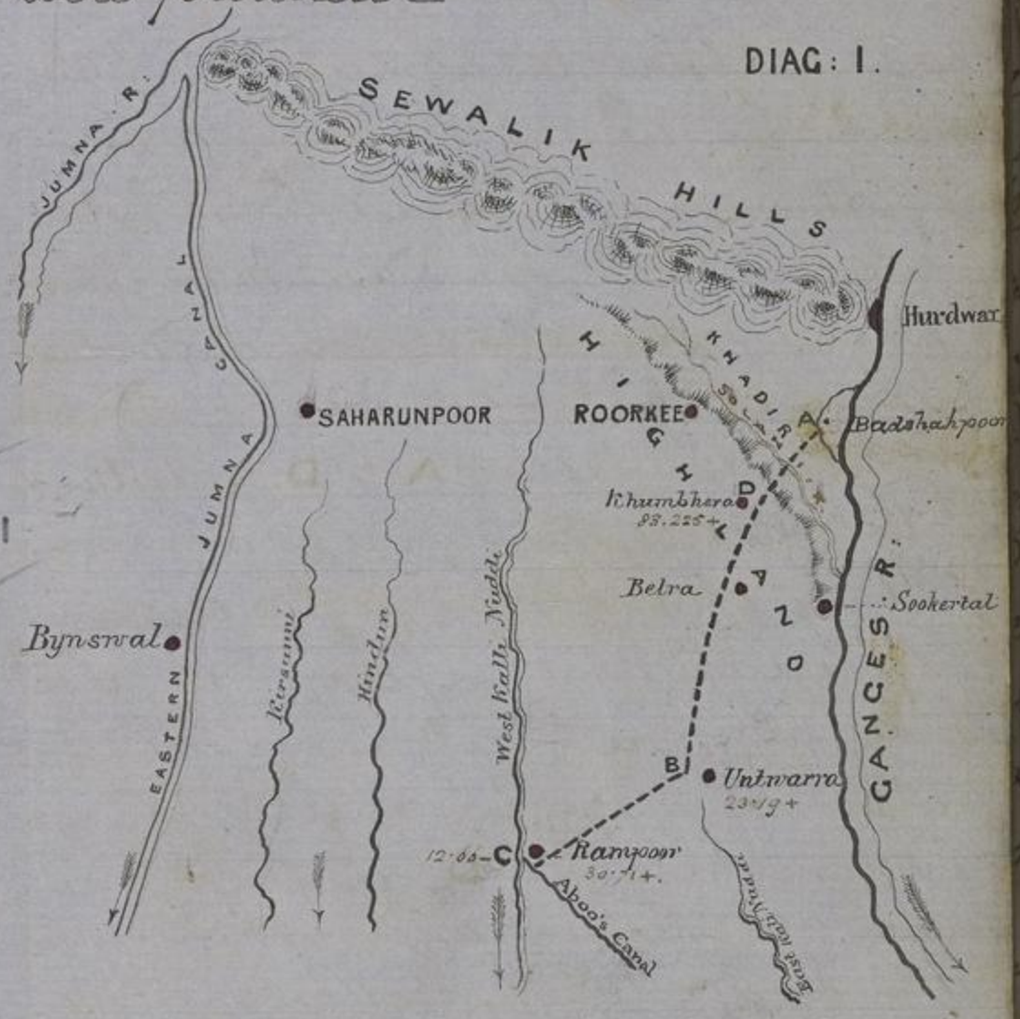
As the famine was chiefly felt in the lower and central dis=tricts of the Doab, and as the evils had after all been only partially relieved by such an enormous sac=rifice of Revenue, the ~~natural~~ question ~~suggested itself~~, as to what might have been the results ~~supposing that~~ a canal for Irrigation had been completed previously to this year of famine; had such a work been executed, the Government would in all probability have been saved this sacrifice of money, and in a moral point of view have been spared the distress of witnessing so much misery. The project of making a Canal from the Ganges so as to pro=vide Irrigation to the Doab was, therefore, no longer to be considered a mere subject of speculation, but ~~to be put to the test~~ at the earliest possible period. My views

~~On~~

regarding it
~~on the subject~~ were explained to Lord Auckland who was at that time Governor General, with a recommenda=tion that Government should au=thorize the disbursement of a few thousand Rupees for an examination of the Khadir to prove the practicabili=ty or not of overcoming the dif=-ficulties which were supposed to exist in that region. His Lordship having approved of this measure and having directed me to carry on the enquiry, I proceeded to Hurdwar and commenced Sprations early in the Month of December 1839.

My design for carrying out these Sprations will be best explained by a diagram, and by a detail ~~an explana=tion~~ of the data on which my views were founded —

DIAG: I.



B.1

The line of levels which had been taken by me in 1836 is shewn by the dotted line; it commenced from the surface of the water in the Bangun=ga near the village of Baushahpoor, which is situated 23 Miles South of Hurdwar — From the point A the levels

levels ran for a distance of 40 miles (impinging on the head of the East Kalli Nuddi at B, or at the village of Untwarra marked in the above Dia-gram) to the point C on the west Kalli Nuddi; it was at the point C im-mediately under the village of Ramproor, that the Head of Muhummud Aboo Khan's Canal was situated, and where the Dam proposed by Captain Debude was to have been built.

The following results were ob-tained from the above line of levels

The point A 83.225 feet below D
A 23.19 feet below B
A 12.33 feet above C
A 30.7 feet below the land on which the village of Ramproor stands. In other words on a line of 40 miles, or from the surface of the River near the village of Baushahproor, to the surface of the west Kalli Nuddi at Ramproor the fall is only 12.66 feet: and to the surface of the high land on which Ramproor stands there is an actual rise of 30.7 feet.

From the point A to D, a distance of 10½ miles, the land is almost entirely on one level for the distance of 9 miles; at this point it rises suddenly until it gains an ele-vation of 83.225 feet near the village of Kumbhera at D; its slope on-wards towards Ramproor may be estimated at 2¾ feet per Mile.

The debouche of the Ganges into the plains lies at least 25 miles lower on a latitudinal line than that of the Jumna. The Eastern Jumna Canal which leaves the Jumna at the point of debouche from the Hills, has opposite the Town

of

of Saharunpoor (which nearly is on the same parallel as Hurdwar) (ost 300 feet of level; The Eastern Jumna Canal at the Village of Bynswal, which is ~~directly on the same parallel as~~ similarly situated to Belra, is 125 feet below Saharunpoor. Taking therefore the known Barom-etrical heights of Hurdwar and Saharunpoor, and reducing the canal levels accordingly, the follow-ing results were arrived at:

	Above the Sea		Above the Sea
Saharunpoor	1013	Hurdwar	1024
Bynswal - on the Eastern Jumna Canal)	888	Belra	888?
Total fall from Hurdwar to Belra	Feet 136		

I assumed, therefore, that the village of Belra was not very far different in Barometrical height to that of Bynswal, and that as by taking a circuitous route from Hurdwar to Belra, which could hardly under any circumstances exceed 50 Miles in length, the object of my Survey was evidently attainable even were the land at Belra much more elevated than I had assumed it to be. The line of Operations for the Survey therefore, was suffici-ently clear, it resolved itself into a simple examination of the ground between Hurdwar, and the Westerly portion of the Khadir both above and below Roorkee, and, to use the words of my original re-port to the Government, "the only "objections (supposing that my as-"sumed height of Belra is correct) "to the project depend upon the state "of the Country's surface in that "direction; if a connected ridge can be

"be discovered only broken by the
"Escape of the Solani, this River
"would I imagine offer no un-
"conquerable impediment to a
"Canal"

By feeling my way along the Country westward of Burdwan, and embracing the westerly portion of the Khadir by circles of levels in numerous sweeps both above and below the true line upon which the Canal would take its course; this true line exhibited itself in two ~~Courses~~ directions; the first, extending very much to the west by which the line of Canal bed would continue in soil; the second, a more direct line ~~by which~~ crossing the valley of the Solani River ~~would be crossed~~ by an Aqueduct. The One had a very extended ~~course~~ circuit, stretching far to the west into the high land which forms the heads of the Solani River, and thereby coming in contact with a great quantity of Mountain drainage; the other ~~had a more direct course, but~~ was more direct, in avoiding the forests and drainage which the first ~~other~~ line had to contend against, it necessitated, however, the crossing of the valley on high levels, and the construction of an Aqueduct, the Cost of which was great. —

After completing the Survey of the Khadir tract, and satisfying myself of its being suited to the required purposes, I continued a Series of levels both longitudinal and transverse to a point near Mynpooree. I had during my Survey at Burdwan measured the discharge of the Ganges River, the supply of which in the Months of December and January

December and January was equal to 8000 Cubic feet pr. second, and ∴ therefore capable of providing for any demands that we might make upon it. I had in my progres down the country observed that material of all sorts could be pro=-cured without much difficulty; and it appeared to me that in submitting a project to Government, it was desirable to produce one on a minimum scale, in which the cost of the works through the Khadir would be met by a sufficiently remunerating return on the Irri=-gation which lay below that tract, the Estimate in fact which I pro=-posed to submit was intended to shew the smallest amount at which a canal could be made with advantage; and having explained the facilities that ex=-isted both in material and in a supply of water, together with the means of carrying that supp=-ly over the difficulties of the Ganges Khadir, ~~to leave it~~ I left it to the Government to determine whether by the construction of a larger and more spacious channel, the extent to which the water of the Ganges could be applied to irri=-gation in the Doab might not be taken the fullest advantage of.

My report and Estimate on the Ganges Khadir is dated 30th June 1820, the amount of the latter was Company's Rupees 10,00,113

The Supplemental report on the prolongation of the Canal down the Doab is dated 15th August 1820 and the Amount of the Estimate which accompanied it, 15,91,045

Total Comp'y's Rupees 25,91,158

The foregoing includes 255 Miles of Main Canal, 73 Miles of Branch, and the necessary Machinery for converting the Main into a Navigable line.-

The return which was calculated on the average of that from the Irrigation Canals on the Jumna, was Estimated at about 10 p.cent on the outlay

With reference to the abstraction from the Ganges ~~River~~ of large bodies of water, which ~~in taking full advantage of the means offered to us, we were in all probability on the point of putting into execution,~~ it became an object at this period of the enquiry to establish gauges at different points on the River, and to ~~effect~~ obtain as many measurements of discharge as opportunities offered. Water Gauges for measuring the rise and fall of the Surface of the River were established at Hurdwar, Gurmookhteesur, Futtehgunh, Cawnpoor, and Allahabad; the registers of these Gauges with the exception of the two first, which were entrusted to Native agency, were kept by the Engineers or Civil Officers of the Stations; the Hurdwar, Gurmookhteesur and Allahabad Gauges, were discontinued in consequence of disarrangement by floods, and doubts as to the dependence to be placed on the records, but those at Futtehgunh and Cawnpoor which are to be found in the Atlas may be depended upon, and for the last 10 years will give a very accurate representation of the rise and fall of the Rivers surface

would be the first effect of the execution of the proposed Canal

From a series of measurements for discharge taken by myself at a point on the Ganges just above Hurdwar, I calculated that the discharge which might be considered a minimum at that point was equal to 8000 Cubic feet pr Second, an amount that did not differ in any great degree from that which was formerly given by Captain Herbert from measurements taken by him about 10 years before when he was employed on the Himalayan Survey. -

At the Gurmooktesur Ghat, a point situated below the Shingle by Capt. A.D. Turnbull Bengal Engrs a set of observations was made simultaneously with those at Hurdwar, the time selected was early in March when the River is supposed to be at its lowest, and just before the melting of the Snow of the Mountains leads to a rise in the ~~River~~ surface. I ~~was in hopes~~ hoped by making these measurements in March to obtain the minimum discharge of the ~~Ganges~~ River, and the uniformity of the results of different ~~measurements~~ trials gave me great confidence. ~~as to their correctness~~ in the general results; These results ~~of these measurements~~ were as follows: -

	Discharge pr Second
Hurdwar 1st March 1842	= 7166·1891
Gurmooktesur 1st Do	= 8685·2194
2nd Do	= 8883·195
25th February 1842	= 8681·894

Gurmooktesur is situated 95 miles South of Hurdwar, and the excess of volume at the former point is to be accounted for by the River having in its course received all the drainage of

of the Khadir, including that from the Puttri, the Solani ~~and~~ with its tributaries, and the different ~~drainage~~ water lines both on the right and left ~~side~~ banks of the River. The results of the measurement at Hurdwar it will be observed shewed that in the driest season of the year, we might depend upon 7000 Cubic feet p^r Second, and the Establishment of Gauges at different points ~~down~~ on the course of the River would hereafter, when a body of water had been abstracted for Canal purposes, shew the effects ~~upon the River of the abstraction of that body~~ of that abstraction on the surface level of the River.

The Government of India having been satisfied of the advantage that the high land of the Doab would derive from the introduction of Irrigation, and ~~having~~ being convinced from the Plans and Surveys ~~of the knowledge~~, the practicability of overcoming any Engineering difficulties that might occur in the Khadir; ~~submitted its recommendation~~ recommended to the Court of Directors that the works should be designed on a scale capable of taking the fullest advantage of the supply available at Hurdwar. The Court in their despatch dated 1st September 1841. recognize the importance that is attached to works for Irrigation and to their financial benefits, and observe that "apart from the consideration of financial results, "which we are far from contemplating "with indifference, there are few "measures connected with our

revenue

"Revenue administration in India,
"more calculated to contribute to the
"general improvement of the country,
"the amelioration of the condition
"of the people, and to raise the
"character of the Government, than
"those of the nature now under our
"consideration; we concur in opin
"ion with the Government of Agra
"that a higher ground for advocating
"these works is found in the security
"which they afford against famine
"and its attendant horrors." "Two
"years" Mr Robertson* remarks "
"have scarcely passed since the
"very country through which the
"proposed Canal will be excavated,
"was laid waste by a famine, which
"cost the lives of thousands and
"presented a scene of suffering still
"fresh in the recollection of all classes;
"to such another visitation the Canal
"will afford a palliation if not a
"remedy" "Influenced by these
"considerations which are strengthened
"by the observations contained in the
"Minute of the Governor General
"dated 3rd April 1841, and relying
"on the discretion of your Government
"with reference to the period of com=
"=mencing and in carrying this
"project into execution with due cau=
"=tion, and with a strict regard to
"economy, consistent with the im=
"=portance of the work, we have re=
"=solved to give our sanction to the
"proposed undertaking on such a
"scale as may be consistent with "
"safety to the works, and the accom=
"=plishment of the important objects
"contemplated in their construction"

On

* Mr Thomas Campbell Robertson
Dep. Gov. of the N. W. P. from
to

On the receipt of the dispatch from which the above is an extract, a Committee consisting of Major Abbott of the Engineers as President, with Captain Baker of the Engineers and myself as Members, was directed to proceed to the ground and report on the efficiency of the proposed works, the probable success of the undertaking, the scale on which it should in the first instance be carried on, and the precise measures to be recommended for adoption; the letter conveying this order was dated Military Board Office 24th November 1841 and on the 7th of February following, the Committees report was submitted to the Government. I may remark here that the attention of the Com=mittee had also been called to the following points: 1st the pro=bable effects of the abstraction of the maximum supply of water on the navigation of the Ganges. 2ndly The probable cost of extending the Canal to Allahabad. 3rdly The probable return from the work. On the first of these points I shall have more to say hereafter, but in the meantime, the Committee when recommending the abstraction of 6750 Cubic feet per Second, or very nearly the whole of the supply in the River ~~at the Head~~ at Hurdwar during the driest months, came to the following conclusions founded on the analagous example of the River Jumna; "during 2 months, January and February of each year"; the Committee remarks "The whole apparent supply is

diverted

"diverted from its channel to feed
"the two Canals East and west,
"yet the undercurrent which per-
"colates the gravelly bed, together
"with the drainage of the inter-
"=mediate country, furnishes a
"navigable stream of water at the
"station of agra, a distance of
"260 Miles by the River's course,
"and the Committee infer from
"this example that in abstracting
"6750 Cubic feet from the Ganges
"supply at Kunkul, which during
"the dry season is estimated at
"8000 Cubic feet per second, the
"Navigation of this River will not
"be injured below Cawnpoor. - Be-
"=tween that point and Gurmooktesur
"Ghat, the Navigation for the larger
"classes of River craft will probably
"be impaired, if not altogether
"stopped, therefore it appears to the
"Committee to be absolutely neces-
"=sary that the Main line of Canal
"from Kunkul to Cawnpoor should
"be rendered completely efficient
"for navigation"

The Committee considered that it was in every way desirable to provide Irrigation for the whole of the lands lying between the Hindun and Ganges Rivers, and that this should be combined with Navigation; to effect these objects it would be necessary to use 6750 Cubic feet per second of supply - This supply the Committee observe "will
"be found ample to carry one Main
"Line of Navigable Canal from
"Kunkul to Cawnpoor, and to sup-
"=ply irrigation to the whole district
"bounded by the Ganges on the one
"side, and by the Hindun and the

Jumna

3rd June/53

"Sumna on the other.-

The straight line by Aqueduct (the Aqueduct being faced by Revetments in the form of Ghats) was preferred and recommended by the Committee after a careful investigation of the ground, especially of that on the circuitous route, over which a Levelling Instrument was passed; the preference to the Aqueduct line was ~~determined, on~~ given on account of the many difficulties which attended the other in crossing numerous lines of drainage by Dams constructed across the Sandy beds of Rivers on steep slopes; Estimates, however, were submitted for both lines, and the following detail left the adoption of either one or the other to the judgment of the Government.-

On Aqueduct Line

Cost of works in the Khadir up to the Town of Roorkee		1870835
Cost of works from Roorkee to Cawnpore		2701220
Do	Futtiguch Branch	622540
Do	Dupsoul do	184520
Do	Shekoubad do	677140
Do	Allahabad do	291580
5 p.c. Contingencies		317391
Total Cost Rupees		6665226
Cost increased by building Ghat Revetments		561180
Grand Total Cost of Aqueduct Line Rs		7226406

Circuitous Line without Aqueduct

Cost of works in the Khadir	Rs	1188335.14.0
Do from Roorkee downwards, including Branches as before		4476920.0.0
5 p.c. Contingencies		283262.12.8
Grand Total Cost without Aqueduct		5948518.10.8

From

From The investigations of the Committee on the subject of returns ~~will be found in Appendix A~~ it was calculated that Irrigation would be provided for 2303 Square Miles, the return upon which at the average rate of 10 annas for Beegah would be equal to $\frac{\text{Sq: Miles} \times \text{Bigas} \times \text{annas}}{16} = \frac{2303 \times 1024 \times 10}{16} = 1486420$ Rupees, independently of the collections for Mill rent, transit duties, and the miscellaneous sales of Canal produce.—

In closing their report the Committee recommended that no time should be lost in commencing the manufacture of Bricks at those points, which are common to both the straight and circuitous line, and that Captain Cautley ~~may~~ should be permitted to commence at once the Main Trunk from Roorkee onwards, to Cawnpoor, completing all the Masonry heads of Branches, and excavating such portions of the Branches themselves, as the Executive Officers may find it in their power to undertake.—

It was also recommended that a Staff of 3 Executive Officers, 6 Assistant Executives, and Twelve Overseers should be placed at Captain Cautley's disposal

During the whole preliminary ~~through which the circumstances~~ above adverted to ~~narrated occurred~~, Mr T. C. Robertson who was holding the reins of the Government of the North western Provinces, and who from his appreciation of the value of the Jumna Canals, looked with extraordinary interest and favor ~~to~~ on the Ganges Canal Project, exerted every energy to break ground, and to advance

advance the progress of the works. The time, however, was that of our ~~Afghan disasters which, with a change of administration in the head of the Supreme Government, were sufficient, perhaps, to account for a want of sympathy which in refusing the aid of Assistant Engineers, left me to carry on the work as well as I could without it.~~

disasters in Afghanistan and the
these combined with a change of the
heads of the Supreme Govt may per
be found as sufficient explanation of
that want of sympathy with the Pro
which by leading to my being refused
aid of Assistt Engineers left me
carry on the work as well as I co
without it.

On the 25th February 1852 orders were issued by the Agra Government for the commencement of the work on the terms of the Committee's recommendation, and on the 16th of April following ground was broken in the neighborhood of Kunkul by the commencement of the excavation of the Channel. At the same period also Brickmaking was ~~established~~ commenced at different points on the line under the supervision of Mr Wright, an Uncovenanted[x] Officer who was under my orders on the Eastern Jumna Canals. At this period also Lieutenant Turnbull of the Engineers was detached by me from the Eastern Jumna Canal works, to commence operations on the high land from Roorkee downwards; so that with the means at our disposal we had in the Month of July 1852, lined out nearly One hundred Miles, collected a large quantity of Materials, and had excavation in full progress at three different points. -

[x] not in the Civil or Military service of the Company

As far back as May of the same year some doubts had been expressed by the Supreme Government as to the propriety of proceeding with the works, and various reasons were alleged for entertaining this view ~~of the Question~~; - My Application

in

in fact for Stuff had been met by a desire to suspend for the present, the arrangements and appointments which I had recommended, ~~in consequence of~~ on financial and other considerations. The collection of Material, and Excavation, however, were allowed to proceed, until the Month of July, when the Supreme Government in a letter dated 21st of June 1842, to the address of Mr Hamilton the Secretary to Government N.W.Ps, in directing all the works to be stopped, called for Statements of Expenditure upto the time of closing the works, with a report upon their ~~present State~~ ~~which had been done upto that period~~. My report which accompanied these Statements was dated 7th August 1842, it referred to a letter addressed to the Military Board by Colonel Stuart, Military Secretary to the Government with the Governor General, dated, Allahabad 29th June 1842 (8 days after the letter from the Supreme Govt ~~Mr Beamish's letter~~ just alluded to above to Mr Hamilton, had been written) ~~and addressed to the Military Board~~, by which it appeared that ~~it was the wish of the Governor General~~ the intentions of the Governor General had been modified, and that it was now his wish that the works should be prosecuted on the principle established in Mr Hamiltons letter No 980 of the 17th June 1842; ~~as on this Report~~ I in my report stated that in consequence of having received the Military Board's orders conveying those of the Government dated 29th June " I had directed "the daily parties to be again "entertained; at the same time "it would relieve me from much "anxiety if Government would at "once place a limit on my Annual "Expenditure, which will enable me

to

"to work satisfactorily under the
"conviction that I am strictly
"agreeably to the wishes of Govern-
"ment". — I observed that a
Lakh or Two of Rupees pr annum
would enable me to carry on work
very steadily with the Small Estab-
-lishment at my command; "both
"Brickmakers could be entertained,
"and about 50 or 100 Earth contractors
"might be kept in employment;
"if only half a Lakh, or even a Smaller
"Sum was allowed, I can regulate
"my expenditure accordingly"

The Statements that accompa-
-nied my report, above alluded to,
shewed that up to the 1st July
1812, the actual expenditure and
liabilities had amounted to
Co Rs 138198.. 8.. 3.

The Supreme Government
in their Military Secretary's letter
No 38, dated 17th September 1812,
~~and~~ in replying to the above re-
-port, observe "In compliance
"with Captain Cautley's wishes,
"and for the purpose of obviating
"any misconception of the wishes
"of Government, the Governor General
"is pleased until further orders to
"restrict the annual expenditure
"on the Ganges Canal, Salaries and
"Establishments included, to Two
"Lakhs of Rupees". —

The above precis of Correspondence
which took place, will throw some
light on the interruptions which were
experienced in ~~the~~ the early days of
progress; a variety of difficulties
had been urged by parties, and
these difficulties had been answered;
an error in my original report
due to the omission of a decimal point
by which the proportion of Surface

of

of the Doab which would derive benefit from the Canal, was much exaggerated, was brought forward; and it is possible that this error had some influence on the indecision which the above correspondence exhibits. The error was undoubtedly an unfortunate one, but it vitiated none of the calculations, on which the merits of the project were based, ~~and as such required little explanation~~. The probable effects of Earthquakes were brought forward as ~~opposed~~ obstacles to the construction of the Solani aqueduct. The destruction to the Navigation of the Ganges was urged as a sufficient cause for not proceeding with the works. The effects in a sanatory point of view upon the Districts which compose the high lands of the Doab by introducing miasmata were urged with a preseverance ~~worthy of a better cause~~. The works however, had proceeded too far to be violently stop'd, and under the restrictions pointed out above, they proceeded steadily, with the ~~full patronage~~ cordial support of the Agra Government, but with little countenance from other quarters.

and this was immediately and most fully explained, especially by the Military Board in their letter No 2294 dated 17th August 1842 to the Sect Govt of the North West Provinces

scarcely justified by the information at command.

My duties and responsibilities meanwhile had been progressively extending, the Executive duties of the Canals in the Dehra Doon, had been added to those of my specific appointment as Superintendent of the Eastern Jumna Canals; in addition, I had at this period the whole of the responsibilities of the Ganges Canal works and its expenditure.

The Supreme Government in the Month of July 1843 placed me in independent control of the

Canals

Canals in the Doab relieving me from Executive duties; and on the 21st February 1843, I had the satisfaction, of obtaining the services of Lieutenant Richard Strachey of the Corps of Engineers, for the Executive duties of the Ganges Canal. No additional expenditure to the 2 Lakhs already granted, however, was authorized, and the Gwalior Campaign which took place at the end of 1843, still further reduced the chances of obtaining aid from the Government, and still further destroyed the hopes that I had at one time entertained of being permitted to push the works on with proper vigor.

At the period of my giving over charge of the Executive duties to Lieutenant Strachey the Amount of Expenditure was thus:

Excavation Cos Rupees	73970. 9. 4
Materials and Sundries	36988. 0. 0
Total Expended up to 1st March 1843 Rs	110958. 9. 4

Early in the cold weather of 1843/44 the levels of the Doab which ~~had~~ in my Survey of 1839/40, ~~stopt~~ had been completed only to ~~at~~ Mynpoorie, were pushed forward to Cawnpoor and Allahabad, and the whole of the Cold Season of 1843/44 was passed in ~~completing~~ perfecting the levels and reconnoissance of the Country. The completion of this Survey enabled me to draw up a full report and Estimates of the Canal works; these were submitted to Government, and are dated 12th February 1845.

Before entering into a detail of this report, I must observe that previously to my undertaking the Survey above alluded to, the

Supreme

Supreme Government had decided that a total modification of the original design should take place, and to use the words of the Minute to which my attention was directed "it should be in the first instance "a Canal of Navigation, and all "the water not required for that "purpose may be distributed "for the purposes of Irrigation" The Main Trunk in short was to be directed upon Allahabad, ~~to that point, the point to which~~ ~~that point where the River~~ Steamers now ascend the River: the Original Project therefore, ~~of~~ where the Navigable line ~~of~~ was carried merely to Cawnpoor, having been thus merged into one of considerably greater length, and (as connected with Irrigation) into one leading to much greater difficulties, I submitted three Projects which will be explained hereafter, noting at the time that I had endeavoured ~~so~~ as far as ~~was~~ was in my power, not to lose sight of the purposes for which this Canal was originally projected, and to provide means for Irrigation as extended as the Security for Navigation to Allahabad would admit of

With these ~~Object in~~ views I placed before the Government Three Projects with Estimates of the Cost of each appended to them

The 1st Project was one where in the Main line had a declivity of bed varying from 2 to 12 inches per Mile, with Falls and Locks attached, to overcome the superfluous slope of the Northern District, and with works of ascent and descent into the Jumna River at Allahabad. Efficient Means for Irrigation on the main line were provided in this Project for Irrigation on the Main

~~as far as~~ as ~~Mainline to~~ the boundary of the Cawnpoor and Futtehpoor District, in advance of which they were somewhat interfered with by the depth of the Excavated channel.
In addition to the mainline, the following Branches for Irrigation were proposed

Futtihgunh	Branch	160	Miles in length
Bolundshur	Do	70	do
Etawah	Do	172	do
Cawnpoor	Do	43½	do

This line is an artificial River constructed on the same principles as the Canals now existing in the North western Provinces.—

The total Amount of the Estimate on ~~this~~ project No 1. was Rs 10,23,66,43.. 14.. 11

The 2nd Project differed from the 1st in continuing the main line from the boundary of the Cawnpoor and Futtehpoor districts to Allahabad, by a System of Reservoirs with Locks to the Jumna, and extending the Cawnpoor line of Irrigation to the neighborhood of the Town of Cawnpoor, the tail water being discharged into a Ravine or tributary connected with the Pandoo River near that place, or if such disposal was more convenient by using it as the means of supply for an Irrigation Channel bearing upon ~~such convenient, by using the water in Irrigation by a water Course bearing upon a point where~~ point where the Pandoo unites with the Ganges River

The total Amount of Estimate on this 2nd Project — was. Rs 97,03,558.2.9

The 3rd Project differed from the 1st in continuing the Navigable line

line from the boundary of the Cawnpoor and Futtehpoor districts to the Jumna near the Town of Dar, turning from thence to the South and connecting the Canal with the Jumna at a point opposite the junction of the Kane River. In this Project the ~~The~~ Canal which ~~was~~ for the last 80 Miles had run contiguous and parallel to the Rinde River ~~would~~ ~~will~~ in fact ~~in this project~~ have maintained its relative position to that ~~Rinde~~ River until it falls into the Jumna. The Cawnpoor line was designed to be navigable and locked into the Ganges with a branch for Irrigation towards the junction of the Pandoo ~~and Ganges~~ that river and

The total Amount of the Estimate for this No 3 Project was 933974 Rs 6. 12. 6 a/c

It was evident that to carry out any of these modified plans, works of a much more extensive nature than those originally contemplated would be found necessary. The determination to make the main line navigable to Allahabad instead of to Cawnpoor led not only to an excess of length in the Excavated Channel, but the flatness of the Country through the Districts of Futtehpoor and Allahabad rendered it necessary to restrict the declivity of bed for the last 173 Miles to 12 Inches per Mile, and to increase proportionably ~~leading to a great increase in~~ the area of the Excavated Channel, so as to effect a discharge of the calculated volume of water:- With such a length of Navigable Channel it was found convenient to straighten the course of the Canal between Rookee and Mynpoori, thereby bringing

bringing the calculated fall between those points on a much shorter distance; the necessity of additional arangements for disposing of this surplus slope was obvious ~~by re-quisite~~; another Mgsonry Fall therefore, was projected at Boodpoor in the Saharunpoor District, for clearing out the tail of which further ~~additional~~ excavation was ~~necessary~~ required: Many works in the shape of Aqueducts, and means of crossing Rivers, which were not anticipated by the Committee were included in the present Esti-mates, and in proposing means for still further securing the Sta-bility of the works, ~~were~~ on the Solani Valley the cost of these works was materially increased. In all these projects it may be remarked that the efficient drainage of the Country through which the Canal passed, had been one of the leading points of enquiry, it had in a great measure influenced the direction in which the Canal had been car-ried, and had on all occasions been considered as one of the first points for investigation.

The above Estimates were framed supposing that the on the Solani River in the Ganges Khadir ~~being~~ would be passed by an Aqueduct. My report however in including the reduced ~~cost~~ estimates for the ~~that would be incurred by adopt-ing the~~ circuitous route, placed it in the power of the Government to make its own selection. In ~~submitting these Estimates for the circuitous line I remarked, that although the profile was in every way adapted to the purpose of the Canal, and although the original cost is much less, the~~

Numerous

Submitting these Estimates I remarked that the profile on the circuitous line was in every way adapted to the purpose of the Canal, & that its original cost would be much less than that of the direct line. I drew attention however to the fact that numerous Ravines, Rivers, & Cross Drainage lines whereby the course of the Canal would

intersected throughout its whole length were not only very serious objections to the former route on the first construction of the works, but that they increased so much the contingencies of subsequent repairs & maintenance as to make it questionable whether a line subject to so many sources of accident would not ultimately prove much more expensive than the Direct line. The country traversed was perfectly a wild & uninhabited tract & it was evident that want of supplies for the working parties, would be a constant inconvenience. It would have been impossible to avoid inundation at the head of each Dam; communication would have been liable to frequent interruptions; inspection always difficult and unhealthiness is the neighbourhood inevitable. Finally as all our works must have been established at points high up in the courses of the intersecting Rivers, all the evils notoriously due to the excess of slope would have been greatly augmented. On these various considerations therefore the Committee was unanimous in preferring the Direct line by Bajoo-heri & Mahewar with Aqueduct to the circuitous line whereby this work could be avoided.

numerous Ravines, Rivers and cross drainage with which the line would have come in contact, were not only very serious objections in the first instance, but the contingencies of Annual repairs and maintenance of the Embankments on such an extended line, intersected on its whole course by Rivers and Nullas, renders it doubtful whether as a mere matter of Economy the circuitous was preferable to the more direct route, considerations, however, independently of the above, arose as to the wild and uninhabited State of the country through which the circuitous line took its course, want of Supplies would always be an inconvenience, and when to these are added the extensive inundations that would be formed at the head of Each Dam in defiance of the Earthen Embankments, the difficulties of communication, inconvenience of Inspection, and without doubt the unhealthiness of the country itself, with the fact that from the position of all these works, so much higher up the course of the Rivers, the declivity of their beds upon which the Dams must be constructed, would be much in excess and the evils arising therefrom greatly augmented, the voice of the Committee was unanimous in preferring the direct line by Bajoohari and Maheswar with ~~the Aqueduct, to the more circuitous route, by which such Aqueduct would be avoided~~

The Estimates for the Three projects above described based on the adoption of the Circuitous route

in

in the Khadir, were as follows: -

No. 1 Project - Co Rs 9226695..12..4
2 do " 8693610..0..2
3 do " 8329798..9..11

By taking this ~~Circuitous~~ line and avoiding that of the aqueduct, a saving would be effected of Co~~s~~ Rupees 10,09,4..8..2..7, or upwards of Ten Lakhs. —

Previously, however, to the sub=mission of the Estimates above des=cribed, considerable changes had taken place in the administration of the Country; Mr George Clerk (who ~~was~~ had succeeded Mr Robertson, in the Government ~~of the North Western Provinces~~ and ~~who had~~ in the fullest appreciation of all projects for the improvement of the Country, had during his administration given not only his count=enance to the ~~project for the~~ Ganges Canal, but all the aid that he was able to bestow upon it) had resigned his seat to Mr Thomason ~~who when~~ under Secretary to Mr Robertson. ~~had in~~ Mr Thomason in the early days of our progress, had given his deepest attention to the subject of the Canal, to the influence that it was likely to exert upon the welfare of the Country, and to urging on by every means in his power Ener=getic movements to facilitate its completion. - In the middle of 1842, Lord Ellenborough was replaced by Sir Henry Hardinge, who as Governor General reached Calcutta and assumed the reins of Government in the Month of July 1844. —

now Sir George Clerk K C B

At this period my health which after 26 years of Indian Ser=vice had been gradually failing,

determined

determined me to proceed to Europe, and early in February 1845, I left the North western Provinces, having made over charge of the Ganges Canal works to Major W. E. Baker of the Bengal Engineers

Chapter VI
Intermediate period under the Directorship of Major W. E. Baker From 1845 to 1848

The State of the works at the period to which I have alluded in the last Chapter, ~~was~~ corresponded with the ~~was equal to the~~ Amount of Annual Expenditure that had been accorded to us by the Supreme Government; Bricks had been burnt and collected at numerous points on the line from Hurdwar to ~~the Country~~ below Meerut and Sirdhunna; Masonry work had been commenced on a small scale ~~on~~ at the Dam and Regulator at Myapoor, ~~the site of~~ the commencement of the Excavated Channel above Kunkul; Workshops had been built at Roorkee; Chokis posts had been Established at Myapoor, Roorkee and Munglour; and a considerable portion of the Channel between Myapoor and the Town of Jowallapoor had been roughly Excavated; Excavation had also been commenced upon on the high land of the Doab near Munglour, and lining out had been Completed for about 100 Miles South of that place

When I delivered over charge to Major Baker the amount of annual expenditure to which we were limited was Two Lakhs of Rupees. For the management of this Expenditure there were two Executive Officers, Lieuts Strachey

and

and Turnbull of the Engineers, and two Uncovenanted Assistants, Mr Wright and Mr Read, to assist them.—

War and its consequences on the improvement of the country, and the progress of works of public utility, appeared to be perpetually the rock upon which the advancement of these works was to be wrecked. It may be said that, originating as it did during the commencement of the Afghan war, ~~it~~ the Ganges Canal was nursed at a period of intense trouble to the State; its weary progress was unwillingly prosecuted during the whole of a warlike administration, in which the return of the Armies from Afghanistan, and fierce battles with the Mahratta chiefs were the ~~events~~ most remarkable events.— The early part of the succeeding administration ~~was marked~~ distinguished by the Sikh invasion, and the consequent demands ~~upon the resources of the Country in no~~ ~~usually heavy drains~~ on the public Treasuries; ~~led to~~ it was marked by still further interruption to the progress of the Canal; Major Baker and his two Engineer Assistants in joining the Army which was concentrated on the Northern frontier had, in fact, by their departure, virtually put a stop to all further progress, excepting that of continuing Contracts which had already been entered into, and it was not until the close of the war, and on the return of those Officers to their respective duties that the subject of the Ganges Canal Works was allowed again to occupy the attention of the Government.—

In

In the interviews that I had with Lord Hardinge previously to my departure from Calcutta in 1845, I had gathered from His Lordship the especial points which had influenced parties in their objections to the project; these re-solved themselves into the injury that would be caused to the Ganges as a Navigable River by the abstrac-tion of water for the Canal supply; and to the probable effects upon the high land of the Doab by the introduction of Malaria from Ir-rigation.- As these were the two leading points, and as the first had for the present at least been disposed of; the Malaria question ~~appear to resolve itself into one~~, ~~which would~~ was naturally ~~fall under~~ me for ~~Medical~~ Sanatory Specific enquiry.- For this pur-pose a Committee was assembled in November 1845, and on the sub-mission of ~~their~~ its report in 1847 the whole question of the Ganges Canal ~~works~~ was brought under the notice of Government.- In March 1847, the Governor General visited Roorkee and the site of the

---

※ The Committee which commenced its Ope-rations on the 30th November 1845, and had proceeded through the Irrigation Districts of the Canals West of the Jumna as far as Hissar, was broken up at that stage of their labors for the purpose of its Mem-bers joining the Army of the Sutlej.- On the 1st of November 1846 the Com-mittee resumed its labors and completed ~~their~~ its investigations.- ~~Their~~ Its Report which was dated 3rd March 1847 was presented to the Governor General on his visit to Roorkee.-

Of this Committee, Major Baker of the Bengal Engineers, was President, and Dr Dempster of the Bengal Medical staff with Lieutenant H. Yule of the Bengal Engineers, were Members

the proposed works in the Ganges Khadir; and it was on this visit that the vigorous prosecution of the ~~works~~ undertaking was determined on. During this period my sojourn in England brought me in ~~con~~ contact ~~section~~ with those whose views on the Navigation and Malaria questions, led them to doubt the policy of continuing the Canal works. As these Questions had con=siderable influence in party feel=ing towards the project, I will here interrupt the thread of my narative by explaining the views of them that had been adopted by myself and others who were advocates for the Establishment of the Ganges Canal ~~works~~. I will take up the Questions as they were argued, beginning with that on Naviga=tion; or, "On the probable effects "to the Ganges as a line of Navi= "gation to Allahabad, arising "from the abstraction of 6750 "Cubic feet per second from its "volume at Hurdwar" The arguments which were used by me may be thus explained.

The discharge of the Ganges at Hurdwar, during the driest season of the Year, or that previous ~~to~~ to the melting of the Snow in the Mountains is calculated at about 8000 Cubic feet per Se= =cond; if, therefore, at this period we remove for the purposes of the Canal 6750 Cubic Feet per second, it appears that we leave only 1250 for the supply of the River.

There is a peculiar feature attendant on the tract of Country lying at the foot of the Sewalik Hills as connected with Springs,

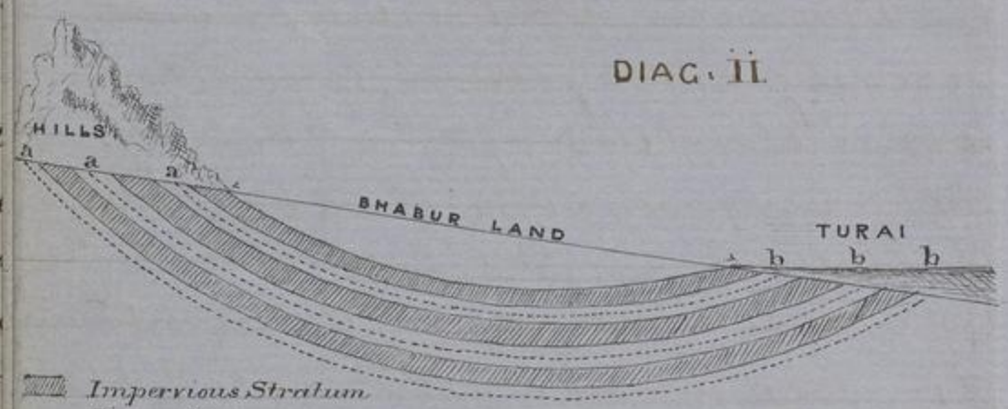
that

that is well known in the Rohilkund
Territory, and is also observable ~~in~~
through the Doab and ~~the~~ west^ward of
the Jumna. In the immediate
vicinity of the passes, and at the
foot of the Hills, spring water rises
to the surface, sometimes exhibiting
itself in mere pools, at other times
in small streams and rills, which
flow for a short distance and then
disappear in the sand and shingle
of the River: parallel to, and South
of this line is a belt varying from
5 to 10 miles in breadth in which
water can only be reached at ex=
=treme and in some cases at un=
=manageable depths; in advance of
this dry tract the Springs rise to
or near the surface forming in Rohilkund
~~forming~~ the unhealthy tract called
the Turai, ~~where the Springs flow~~
~~on the surface~~, in the Doab shewing
themselves generally in the shallow=
=ness ~~to the depth~~ of wells, although
a line traceable from Badaoun near Shergurh to
on the Southern Angle of that part
of the Ganges Khadir with which
the Canal works are connected the
~~action of the Springs upon the sur~~
existence of detached ~~and~~ in some cases
~~face is removed~~, extensive sheets
and marshes as dry ^ to the surface ~~is situated~~ to that
of the Rohilkund Turai. The
cause of this ~~appearance~~ peculiarity
is, that in the whole of the tract
skirting the mountains, there
is a deep seated impervious Stra=
=tum rising near the foot of the
Hills and cropping out on the ^ Northern limit of the
Turai belt. That the water passing
down the Rivers percolates through
the shingle and passing under
this impervious stratum rises
again to the surface at a con=
=siderable distance, leaving the
intermediate space dry. The

following

following Section is explanatory of the views that I hold as to the Springs above alluded to.—

DIAG. II.



It is to be inferred, therefore, that the Establishment of Bunds or Embankments across the beds of Rivers, of which the Ganges and the Jumna are the two principal ones, ~~subject to the influence of~~ exhibiting these Phenomena, at any point between a and b, or on that marked as Bhabur land, would only diminish the supply to a certain extent, and not as would naturally be supposed remove it entirely.—

It is unnecessary to describe the relative positions of the Ganges and Jumna, as these are shewn in the Maps which accompany this paper; but the two Rivers pass through a Country ~~subject to~~ presenting the above peculiarity, similar in its Geological features, and evidently liable to the same action of Springs by percolation.—

In the results that the abstraction of the water for the Delhi and Doab Canals have produced upon the Jumna River at a point opposite Agra, we may obtain an approximation to effects from similar causes, which may arise on the Ganges ~~River~~ at Cawnpoor and Allahabad

and Allahabad

The Jumna ~~River~~ at its debouche from the Sewaliks has a discharge per second equal to 4000 Cubic feet. During the dry months it occasionally happens that the whole of this water disappears at a point below the Canal Heads, it is partly taken off by lateral Cuts into the Delhi Canal on the west, and into the Doab canal on the East, strong bunds being thrown across the bed of the River to effect this ~~purpose~~, and the portion which is not admitted into the Canal Cuts escapes unobservably through the Shingle bed; South, or on the down Stream side of these bunds the bed of the Jumna sometimes has been lain perfectly dry, and to a distance of some miles South no appearance of Springs of any description has existed: long before the River has reached the latitude of Saharunpor however, water again appears, and although fordable at certain points, boats are required at all the Ghats and Ferries for the transport of Merchandise. Opposite Agra, the River is so far Navigable that boats varying from 500 to 1000 maunds laden with Cotton, leave that place for the lower provinces, and as far as I could discover from enquiry amongst the boat people, the difficulty that they experienced was not in the neighborhood of Agra, but immediately above the junction of the Chumbul where the Jumna forms itself into a Shallow rapid, and during the dry months offers an impediment although not an insurmountable one to the passage of Craft. —

about 18 to 36 Tons

The

The average transverse section of the Jumna opposite Agra during the driest months may be Estimated at 900 Superficial feet, that is to say, the breadth is 300, and the Hydraulic mean depth is 3 feet, the Slope of the River is about 1·25 feet per Mile: the discharge, therefore, on the formula which I have universally adopted in all my calculations is* 2061 cubic feet per Second.-

Between the Canal bunds (immediately South of which the bed of the Jumna is perfectly dry) and the Town of Agra, the Hindun River is the only tributary that provides any additional water, and during the dry weather the maximum supply from this source does not exceed 200 cubic feet per second: Neither the Delhi nor the Doab canals pass off Escape water to any amount worthy of consideration:- it appears therefore that in defiance of the abstraction of the whole apparent supply of the River from the Shingle tracts at the Canal heads, the Jumna ~~River~~ opposite the City of Agra still maintains its character as a River navigable to a certain extent, and carries a volume of water the origin of which can only be explained by Springs and percolation.-

Between Hurdwar and Allahabad or Cawnpoor on the Ganges ~~River~~, there are the following tributaries:-

Solani

---

* R = 35·29
b = 1/4224
V = 2·29 feet per Second
D = 2061 Cubic feet per Second

Solani and Bhat Nudies
and Jurai tracts of the
Ganges Khadir
East Kalli Nudi
Yar Wooffadar
Ram Gunga
Eesun

all giving a perennial supply to the Main Stream: the System of percolation which is so manifestly conspicuous on the Jumna may ~~be~~ equally be anticipated ~~supposed to occur~~ in a River placed in its neighborhood, and flowing over a Country similar in Geological character. The extent of percolation (if percolation is admitted at all) will it is presumed bear the same ratio to the original volume on the Ganges as ~~is therein to have taken place~~ it holds in the parallel case of the Jumna. Should this be acceded to, we have the following results (laying aside the supplies of tributaries and assuming that the Ganges Canal absorbs the whole volume of the Ganges as the Jumna Canals do that of the Jumna)

As 4000 : 1861 :: 8000 : 3722 Cubic feet per second; that is to say, that independently of the supply received by the Ganges ~~that will receive~~ in its course from the five Rivers above noted, the volume of water which would pass Caunpoor, under the conditions above ~~supposing that~~ ~~the Canal binds laid the River South of Bundwan perfectly dry~~ supposed would be 3722 Cubic feet per second!- in short that the Ganges River at Caunpoor would when the Canal was in full vigor

Stile

※ 1861 = 2061 - 200 Cubic feet: 200 Cubic feet per second being the calculated supply received from the Hindun River between the Siwaliks and Agra.—

still possess a volume of water
nearly as great as that of the
Jumna, before the Canals on that
River were constructed

The conclusions at which I
arrived from the above investigations,
tended to shew that little or no
interruption would arise to the
Navigation of the Ganges as high
up as Futtigurh, even supposing
that the whole body of the River
as it leaves the Hills was taken
for the supply of the Ganges Canal.
North and above Futtigurh the
demands for navigation are
trifling, and the few boats which
pass up to Gurmookhteesur and
Sookertal (the latter being the
most Northerly point to which
boats reach) would readily be
accommodated in the Canal
itself, and with infinitely greater
convenience as regards the land
Carriage of Goods to the large
Towns and Cantonments in the
Doab. Moreover that were the
Canal to be ~~established~~ traced as a Navi
-gable line from the Jumna up
-wards, it would be preferable
to the main Ganges, ~~and the evils~~
~~if such should arise of the Ganges~~
~~River being injured or deteriorated~~
~~as a Navigable line from Hurdwar~~
~~to Cawnpoor or Allahabad would~~
~~be compensated for~~ As to the
~~Question of the~~ Ganges being affected
below Allahabad or below the
junction of the Jumna, the
question was one of great im-
-portance, but it was one upon
which we had no sufficient data
to guide us; the Maps of India
with the configuration of the drain
-age

and thus compensate fully for the evils it might cause to the stream itself, by the additional facilities for transit which it would thus supply.

=age of the Gangetic valley, and the proportion borne by the line under discussion, to that of the numerous tributaries extending from the Himalayas to the Bay of Bengal, appeared to ~~be~~ supply evidence in favor of those who anticipated no injury to Navigation.-

The whole question was an intricate one; Nobody ~~attempted~~ ever doubted ~~to doubt~~ that the abstraction even of the smallest possible quantity of water affected to a certain degree the Navigation of the Ganges. but the effects were ~~was~~ merely in ~~one of~~ degree, and the general results ~~advantages~~ of the Enquiry ~~state~~ appeared to resolve themselves into this: "were the evils to Navigation of "a nature so injurious as to "counterbalance the benefits "arising from the Canal?"

To those who considered that the Navigation of the Ganges would not be interfered with by the Ganges Canal, works, the analagous position of the Canals on the Jumna, and the effects they produced ~~exerted~~ on that River, were peculiarly conclusive and satisfactory; a question, in fact, which might have been otherwise perplexing, was if not reduced to a very simple one, rendered comparatively easy.-

The Jumna being a smaller stream than ~~that of~~ the Ganges was more dependent on the Canal heads for its supply; the Canals on the Jumna abstracted at certain seasons of the year, and at periods when the Navigation of the River was least able to afford it, the whole available volume; a great

part

part of this volume, passed off to the Westward towards Hansi and Hissar, and whether by means of percolation or evaporation was entirely lost to the parent River: along the greater portion of its course the Window, which affords a supply of little or no consideration, is the only tributary. On its banks are situated the large Towns of Delhi, Muttra, Agra, Etawah and Kalpi, to which the Jumna ~~River~~ affords the only means of water carriage for all the rich and extensive Districts that lie on its banks; if, therefore, under these circumstances, the Jumna Canals having done their utmost to destroy the navigation, the navigation that exists continues to be of the greatest importance and value; why should the Ganges River, which is less affected by the supply from the ~~Jumna or~~ the ~~Jumna's~~ canal works ~~to be supposed to produce other results on its supply, be placed under greater difficulties~~? The Ganges canal in the first place does not take away the whole of the supply from the Ganges, there are numerous tributaries or feeders scattered along the whole course of the River; the percolation from the canal is confined to its own region, and whether it escapes into the Jumna or the Ganges, is equally available for the purposes of navigation; the absence of all large Towns on the left Bank (or that unconnected with the canal) of the Ganges as far South as Allahabad, with the known fact that the tributaries on that side are imperfectly navigable, reduces to

Some

some extent the value of the Ganges as a navigable line to that par-ticular region; the navigation of the Jumna on the contrary appears to be of importance to many large Towns which lie on the right, a bank unconnected with the canals, to all of which the River provides water carriage. The inferences ~~is~~ are that the abstraction of water from the Ganges at Hurdwar will be of less importance to ~~the Ganges~~ that River, than the abstraction of water for the Jumna Canals is to the Jumna, and I must add that whilst the latter is providing the means of water carriage to some of the most rich, and, in a commercial point of view, most valuable provinces of the North west which lie on its banks, and whilst the Canals which are taken from it, are the source of great wealth and prosperity to the tracts that come under their influence; it seems to me that the Philosophy of denying advantages of a similar nature, to the Ganges which it is proposed to ~~it~~ place under the same regimen is somewhat questionable.—

From the Month of April to the Month of December, inclusive, when the Rivers are either affected by the Melting of the Snow in the Himalayas, or by the periodical rains, the abstraction of water for canal purposes, has less influence than it has in the remaining Months; during those of the rains, when the greatest part of the traffic of the Country is transported by

by water carriage, no sensible effect is produced by the Canals at all, and it is only during the Months of January, February and March, when the supply taken for the Canals bears the greatest proportion to the volume of the River, that the ~~effect upon the River~~ reduction of surface level is appreciable; During this period, or rather during the seven months, which are entirely free from the Rains or their effects, the Navigation of both the Jumna and Ganges ~~is~~ confined to their own lines, the tributaries at this period having no pretensions to being navigable ~~lines~~; the extreme points to which boats reach on the Jumna are during this period Agra and Muttra; On the Ganges, Gurmooktesur and Sookertal. The size of the Cotton boats which reach Agra, gives the tonnage of boats on the Two Rivers in favor of the Jumna, and these Cotton boats to which I refer reach Agra at periods when the whole of the supply of the River is derived from percolation. In the foregoing paragraph I have attempted to shew that the Jumna suffers from the abstraction of water for the Canals to a much greater degree than the Ganges will suffer, and that, therefore, there is every probability of the latter being more favorably placed with regard to Navigation than the former

Whatever may be said as to the effect of the Jumna Canals on the parent River, the fact is a notorious one, and one of which every ~~that~~ resident in these provinces might convince himself, that the

Jumna

7 March 53

Jumna during the whole year con-
tinues to be the line of water car-
riage of a large and flourishing
trade, the best exemplification
of which is in the fleets of boats,
many of them Cotton boats of large
tonnage which are ~~always passed~~ to be seen passing up & down
~~between the Town of Allahabad and~~
~~Opposite the City of~~ Agra.—

It is, however, solely in the
distribution of the volume that
the water which, under the worst
circumstances of Canal interruptions
passes down the course of the Jumna
and Ganges Rivers in their approach
to Allahabad, can be said to be
insufficient for navigation! This
evil arising from distribution,
would in consequence of the excess
of breadth of the bed of the Ganges
shew itself in all probability un-
-der more exaggerated circumstances
in that river than it has done
~~In the Jumna it would~~ in the Jumna, and
shallows rendering navigation
difficult, or even in some cases
~~interrupting Navigation~~ impracticable, might
be the result of an over reduction
of the volume of the River; but
artificial means which lead to
the evil, are at hand to remedy it,
and the process of deepening Chan-
-nels in wide sandy beds is one
so well understood in India, and
can be effected with such moderate
means, and at so small a cost,
that the injury to the navigation
arising from this circumstance
is one properly of no serious mo-
-ment.— As long as there is a
body of water in the bed of a
River sufficient, if properly dis-
-tributed, to ~~effect~~ insure navigation,
it is the fault of the Government
or of those concerned, if there is

no

no navigation; to raise objections to the abstraction of water for canal purposes, when these purposes are acknowledged ~~in an enormous de-~~ ~~-gree~~ to be conducive to the prosperity of the Country, to the increased wealth of the Inhabitants, and consequently ~~to the improvement of the Revenue~~; and when such abstraction leaves an ample supply in the River for all purposes of navigation, if such supply is properly ~~economised~~ regulated; is simply the enunciation of a doubt as to the pecuniary value of the Canal when ~~placed in opposition to~~ contrasted with the cost of rendering the River navigable. It is granted, however, that the Canals for Irigation in these Provinces do return to the Government Treasury the most liberal profits; if a portion of these profits therefore, ~~be expended in placing the large disposable volume which undoubtedly exists in both the Jumna and Ganges independently of the abstraction of supply for the Canals, in a proper position, it becomes a matter of inquiry whether the advantages resulting to Navigation and Commerce in the River itself may not counterbalance the injury caused by the abstraction of the water for canal purposes.~~

From the Hills to Delhi on the Jumna, and from the Hills to Sookertal on the Ganges, the navigation is restricted entirely to Rafts of Timber, and to the passage of boats, which being built in the valley of Deyra, are with some difficulty and great danger floated empty down the rapids; From Delhi

in works for the proper regulation of the large supply unquestionably at command in both the Jumna and Ganges even after the utmost demands of the Canals have been adequately supplied; the advantages resulting from the improvement of the River thus effected may fairly be expected to be almost if not entirely sufficient to compensate the Commercial community for any injury the abstraction of the Canal waters may temporarily entail upon it. *

* Note. On the Influence of the Jumna Canals on the Jumna River, see Appendix Vol. Page

Delhi to Allahabad the Jumna with all its injuries as inflicted by the Canal works, is the only medium of water carriage. The Jumna & Canals themselves afford to the Timber trade in the valley of Deyra, an immense outlet ~~of~~ For wood of all descriptions to the Burriana and Countries to the Westward, as well as to the inland Countries or Districts which are situated above Delhi: at that point, however, the advantages of Canal Navigation cease; nor are the Canals themselves as navigable lines ~~from the debouche of the Ganges~~ from the Mountains to Cawnpoor, on the Ganges. and to a point opposite Kalpi on the Jumna; these lines instead of being dangerous and interupted as the beds of the Ganges and Jumna naturally ~~are~~ would be, ~~would be of~~ comparatively safe and convenient, & During the dry Months to which I have before alluded, the line of traffic on the Canal would be open and unimpeded, and during the Rains, when the water carriage of the Country is in the greatest requisition, and when the ~~Great~~ main Rivers

In such a state of things the ~~The~~ advantages ~~in favour~~ of the Ganges Canal ~~will be on the facts above referred to~~ would be of immense import-ance, it would. ~~would~~ Navigable lines ~~from the debouche of the Ganges~~ from the Mountains to Cawnpoor, on the Ganges. and to a point opposite Kalpi on the Jumna; these lines instead of being dangerous and interupted as the beds of the Ganges and Jumna naturally ~~are~~ would be, ~~would be of~~ comparatively safe and convenient, & During the dry Months to which I have before alluded, the line of traffic on the Canal would be open and unimpeded, and during the Rains, when the water carriage of the Country is in the greatest requisition, and when the ~~Great~~ main Rivers

Rivers themselves, relieved from all ~~removed from the all influence~~ effects of Canal abstraction were giving to the Country the benefits of unimpaired navigation, the Ganges Canal would in its central course between the two Rivers provide additional facilities for the conveyance of merchandise, and give fresh means for the distribution of the produce of the Country.—

So far for the Question of the injury to Navigation; let us now turn to the Counterbalancing benefits derivable from the Canal. I have in the former paragraphs shewn that as a navigable line both in itself and as far as its effects on the parent River, the Ganges Canal has great and favorable claims for consideration are concerned. The ~~great~~ leading and most important fact, however, must not be overlooked that the original idea ~~from which the project for making~~ of a Canal from the Ganges ~~was~~ originated, was for the purposes of Irrigation, and that although mistaken views, at one period of its progress led to ~~the consideration of~~ its being diverted from its ~~original purpose~~ primary object; it has been from the first both in the Mind of the Projector, and in the contemplation of every one who has carefully turned ~~their~~ his attention to the Subject, distinctly a line for Irrigation: its uses as a Navigable Channel being incidental, and entirely of a subordinate Character. To return however to the Counterbalancing benefits which might be expected from opening the Ganges Canal

I

Mr Thomason

I cannot do better than introduce nearly verbatim the expressions made use of at the time by one who is well able to appreciate the true merits of the question.- "To deny," says the writer, "the value of Irrigation to agriculture in India is like denying the value of manure to an English farm!- The difference between irrigated and unirrigated lands is the first rudiment of his profession which a Revenue Officer has to acquire.- It is an axiom in most parts of Hindostan that whatever affords new Irrigation, or cheapens that which exists, gives food and wealth to the people and adds to the resources of the State.- Hence the efforts to multiply wells, to form Tanks and to make Canals all over the Country.- In Rohilkund, on the Jumna, on all the Rivers between the Jumna and the Sutlej the prosperity of the Country depends on Canals.- In Southern Madras the waters of the Coleroon and the Cauvery are used for the same purpose, and works are either contemplated, or are in progress, for turning the waters of the Kistna and the Godaveri to the same account.- In times of drought, Canals support the Cultivators because they bring the water from a source beyond the reach of the periodical rains, and because they give employment and support to a people who would otherwise be helpless.- Famines may arise not only from a want of food, but from inability to obtain it.- During the Famine of 1837/38 there was good reason

to

to suppose that grain sufficient for one or two years consumption was then in Store; in the private granaries in Hindostan there was grain in abundance, and when the Government found the people employment they were able to support themselves on a pittance below the ordinary rate of wages. The Cry was not for food, but for money to buy food. The whole population who lived by tillage & were unable to till, and were therefore starving. If they could have watered their fields from Canals they would have continued to till, and instead of Starving would have grown rich This was notoriously the case on the Punna Canals at the period of the famine above alluded to, the Canal villages grew wealthy, on account of the miseries of their Countrymen. In Ireland, Railways and an open Coast did little to alleviate the famine that raged in that Country; whilst the people were Starving, food was exported from the want of purchasers It was necessary by employing the poor on public works to give them the means of purchasing food. What public works effected in a wasteful and extravagant manner, the Canal is calculated to do in the most beneficial way possible. —

Famines do sweep over India occasionally in a most terrible form, and it is not perhaps much which the utmost human Skill or foresight can do to alleviate them. No Canal can be a substitute for the rain from heaven,

but

but wherever its influence extends it may incalculably lessen the evil - It may give life to thousands, it may save other thousands from utter destitution, and it may save the Government from that financial injury, which cannot but weaken its power, and impair its energy But in all seasons irrigation from the canal will more or less give comfort to the cultivator, wealth to the proprietor, and revenue to the State.- Are all these certain advantages to be forfeited because for a part of the year boats will reach the villages on the banks of the Ganges with some greater difficulty than at present?"*

We now come to the Question of Malaria, as connected with existing canals and its effects on the population of these provinces ~~by the canals of Irrigation~~; together with the increased evils ~~of this description~~ from this source which the opening of the Ganges canal ~~would be all probability engend~~ has been supposed likely to engender.—

In discussing the effects upon climate which may be produced by the introduction of Canals for Irrigation I have in one of my reports made use of the following expressions - "In referring to the low tracts of the Doab and especially to those situated in the Futtehpoor District, my attention has been drawn, during the last two years especially to an opinion which has been prevalent that wherever lines of canal exist in these provinces, the genius of Malaria and sickness holds undisputed authority: without producing proofs that are numerous that

* Note. Remarks by Mr. Thomason Lt Gov. N.W. Provinces -

that the Epidemics which have shewn themselves ~~stayed~~
in Towns and Villages near the Canals,
have been equally felt at others far
removed from the influence of either
Canals or of Irrigation, it is natural
to infer that the introduction of
moisture and excess of vegeta-
=tion on the Surface of Countries
which had been comparatively
dry before, must necessarily lead
to a change of climate: that change
must necessarily demand an
alteration in the habits of the people
subjected to its influence, and there
can be nothing extraordinary
when we look to the way of living
adopted by the Native Community
their lightness of clothing, their in
=difference to exposure to the
night air, their Sleeping on the
ground, and frequently carrying
on their field labors during the
night time, as well as during the
day, in arriving at the conclusion
that by the change of a dry for a
moist climate some modification
of this System is necessary" The
paragraph which I have quoted
is in my opinion the key to a
great deal of Canal sickness that
takes place, the Hygrometrical
differences as shewn by the dry
and wet bulb Thermometers
in regions uninfluenced by Irri-
=gation are extraordinarily great,
and the Englishman fresh from
Europe, or he who has spent the
greater part of his life in the
Bengal Provinces, is surprised
on reaching the latitudes above
Allahabad to find the green to
which his Eye has been accustomed
~~to~~, no longer existing; to find him-
=self

=self in plains as brown as the soil of which they are composed, and with the exception of tracts irrigated totally denuded of verdure; the contrast is a very remarkable one, and the fact does not appear to have been at all understood by those who without having visited the North Western provinces have been called upon to give an opinion on the subject. Very serious sickness had occurred at Kurnal and Hansi, two large Towns with Military Cantonments attached, which were situated on the Canals west of the Jumna, and to these two cases references were made on all occasions as examples of the evil effects of Canals in general. Without data of a more extensive nature than we had at the time, it would have been difficult to say how far the sickness that existed at the above two places, as well as at other portions of the North Western Provinces was dependent on the Canals; At any rate before these most necessary and useful works were condemned, it was desirable to have it proved whether the sickness complained of was confined to their vicinity; whether this sickness arose from Malaria due to the Canal, or to an epidemic common to the Country: it was also advisable to discover, should it be proved that the sickness does originate in the Canals whether such sickness arises from lands irrigated or from Marshes caused by imperfections in the Canal, or from sheets being filled, and allowed to remain as stagnant water. - Waters carelessly used, and allowed to run to waste appeared to be another

another element ~~of~~ in the inquiry, which ought not to be overlooked, whether it is chiefly in the neighborhood of rice or in cultivation in general that sickness is prevalent, and whether by carefully embanking the canals, and removing the evils above mentioned, the health of a country might not be restored. The removal of the cantonments from Kurnal which was situated on the banks of the Delhi Canal, was no doubt a political measure ~~based on~~ ~~removed from~~ the necessity of establishing a mile post more advanced ~~towards post on~~ the Sikh Frontier; this removal however which was popularly attributed to the effects of the Canal, ~~added to~~ with very severe sickness at Hansi a Town situated on the Hansi ~~Canal~~ Branch of it, had been the chief causes for the Canals in the North western Provinces having obtained a character for unhealthiness. The Town and Cantonment of Kurnal were situated on the edge of the high land which skirts the Khadir or valley of the Jumna River; The Delhi Canal which at this part of its course winds through the Khadir on the ancient line given to it by its Puthan Projectors, skirts the foot of the high land on which the Town of Kurnal is built, and to some distance North and South consists of extensive reed marshes, which in the decomposition of Vegetable matter, and in the harbour that they provide for animals and nuisances of all descriptions most indubitably acted very ~~most~~ prejudicially on the health of the neighboring country. At Hansi the Canal from its want of slope and

with its
and consequently sluggish streams
was a nursery for weeds of all ~~descriptions~~ kinds;
moreover, of which Hansi is the
Capital was previously to the
opening of the Canal, ~~entirely~~ in a great measure
~~confined to~~ pasture land; the introduction
of water had entirely changed
the appearance of the ~~country~~ surface
throughout the whole region in
which irrigation extended, and
a richly cultivated had succeeded
to a pastoral Country.- In both
these cases the reasons for the oc-
-currence of sickness appeared
to be sufficiently obvious. They
depended on the abuse rather
than on the use of Canals.-

The Canal in its Northern
parts, and in the neighborhood
of Kurnal, notoriously required
to be remodelled, but Money ju-
-diciously spent on Silt clear-
-ances and in Embankments
would in all probability, have prevented the evil
~~with all the faults of alignement and defects on the faulty line on which it~~
to exist
~~now~~, ~~have remedied the evil~~,
by eradicating the marshes, and
Restricting the water to its own
Channel: Funds, however, were
not available for purposes of this
sort at the period to which I al-
-lude; ~~the Government was a~~
~~warlike Government~~. The sickness
of Hansi arose in all probability
from the ~~causes of~~ effects of Change of Cli-
-mate to which I have before
adverted, added to the want of
Expenditure in maintaining
the Canal Channel clear and
free ~~of Expenditure~~ from silt & weeds.

The Eastern Jumna Canal
which is Embanked, is not liable
to ~~this~~ such marshes as are above referred to
has

has by no means escaped from the Sickness complained of elsewhere; this Sickness having been prevalent at Rampoor, Shamlie, Saharunpoor, and in other large Towns in the Southern Districts, whereas the tracts situated to the North, which from their proximity to the Sewaliks and from their jungly character, have the name of being the most unhealthy, have ~~been~~ comparatively ~~escaped~~ free from Sickness

Previously to 1823, Enquiries had been ~~established~~ instituted by the Government of the North western Provinces, as to the progress, causes and localities of the universally reported sickness arising from the Canals; it was the fashion at that period to make the Canals the Sources of all sickness, and to hold out the removal of the Kurnal Cantonment as the great ~~proof thereof~~ example; the Reports which were called for at this period from the Medical Officers of the different Districts ~~under Canal influence~~, rather tended to mystify than to clear up the Question; - Towns stated to be ~~labouring~~ suffering under the effects of Canal irrigation, were shewn to be at a distance and altogether ~~detached from~~ unconnected with the Canals, and sickness appeared to exist quite independently of Irrigation. A report from the Meerut District ~~authorities of the civil~~ in calling for Medical aid for the population on the Canal Banks, ~~exemplified~~ in a remarkable degree the feeling which led people to conclude ~~that existed~~ at that time, that sickness and fever must necessarily depend on Canal irrigation. The only Canal

that

that was connected in any way
with the Meerut District was the
Eastern Jumna Canal, which irri-
-gated a comparatively small portion of it
lying to the extreme west ~~of the Dis-~~
~~trict~~ and bounded by the Kirsunni
River and the Jumna. At the period
to which I allude there was consider-
-able sickness in the Canal neigh
-borhood, but the same sickness
~~prevail~~ throughout the whole of the Meerut District
. At the Town of Begumabad and
its neighborhood, situated 23 miles
East of the Canal, and separated
from it by the valley of the Hindun River, there
was sickness fully equal to any that
existed in the vicinity of the Canal,
Moradnuggur, and other large Towns,
with which I at that time was ac-
-quainted, and which had no con-
-nection whatever with Canal Irri-
-gation, were suffering precisely
in the same way: There was an
epidemic in fact ~~raging over~~ throughout
the Country, with which I imagine
the Canals were in no way con-
-nected, and yet the Canal neigh-
-borhood only was selected as a matter
of especial reference for Medical
aid! ~~The inference in fact was~~
~~at that undoubted~~, that the Author-
-ities had taken for granted ~~that~~
~~which~~ what had by no means been
proved, and that the reputation
for unhealthiness which the Canals
in the North West Provinces had
obtained (~~as not connecting~~ being unsupported by
the facts ~~which~~ with this Enquiry had
developed) rested on no sound
basis whatever. One question how-
-ever forcibly attracted the atten-
-tion of those who seeing the bene-
-fits conferred ~~upon the North West~~
~~Provinces~~

~~Provinces~~ by Canal Irrigation, wherever it was employd
~~were capable of appreciating~~
~~the prosperity that existed through~~
~~and all the villages which came~~
~~under its influence, and~~ were
therefore anxious to check any mis-
-taken views which threatened to delay
~~their~~ its extension: "Allowing that
"Canal Irrigation leads to sickness
"in its neighborhood" they argued
"Is this Sickness confined to a
"comparatively small portion
"of the population/a population
"that eagerly appreciates the ad-
"vantage of Canal Irrigation,
"and as with one voice
"and assiduously calls for it/to be
"considered of sufficient moment
"to prevent the execution of a work
"which has for its object the salva-
"tion of the many? - Is a sickness
"of this sort to be put in compe-
"tition with the Famine of Guntoor
"in 1833, so graphically described
"by Captain Best of the Madras
"Engineers, in which the loss of life
"was fearful, and that of Revenue
"so enormous that Captain Best
"clearly shews, ~~that~~ it would have
"been worth while merely in a
"financial point of view for
"Government to have expended
"221 Lakhs of Rupees (£2,210,000
"Sterling) to have prevented it!
"Is the Famine of 1837-38, which led to the sacrifice of a million Sterling of Revenue & which
"raged in ~~the~~ the Doab
"~~of~~ the North West Provinces, ~~and~~
"through the ~~centre~~ heart of which the
"Ganges Canal will run, and
"on account of which the project
"~~of the Ganges Canal~~ was specifi-
"cally approved of, ~~which led to~~
"~~a sacrifice in the Revenue of~~
"~~a Million sterling~~, already forgotten?
~~There was sufficient confidence in~~
~~those~~

Those who were connected with the
felt sufficient confidence in such considerations
project ^ to satisfy them that the
progress of a work so intimately
connected with the happiness and
security of our North west Provinces
would ultimately meet with the
liberal attention and fostering
care of the Supreme Government

Whatever might have been the
value of the arguments and opinions
above given, they resolved themselves
after all into mere speculations,
and as such were not likely to
researches
carry much weight. The ~~reports~~
holdover of the Committee to which
I have before referred, ~~and~~ which
was expressly assembled "for
"the purpose of reporting on
"the causes of the unhealthiness
"which has existed at Kurnal,
"and other portions of the Country
"along the line of the Delhi Canal,"
and further ~~the Committee will also report~~
"whether an injurious effect on the
"health of the people of the Doab
"is or is not likely to be produced
"by the contemplated Ganges Canal"
placed the matter ~~fortunately at rest~~
a source of great
~~at any rate~~. The results of the
Committee's labors were arrived
at after the most patient ~~investi-~~
Examination
~~-tigation~~ of the population ~~visit-~~
~~-ing~~ in villages the lands of which
were irrigated by the canals; the
members were of high professional
and scientific acquirements, and
they were called upon to reply
to certain categorical questions,
answers
the ~~replies~~ to which must have
been in one way or the other
conclusive. As the Report of
this Committee is one of great
importance, not only to the Ganges
Canal works, but to the ~~future~~
~~hereafter~~

~~because of the~~ future extension of artificial Irrigation in the North West Provinces, I have in Appendix B given ~~the paper~~ it in extenso, and shall content myself here by noting the principal conclusions at which the Committee arrived:-

1st That an extensive epidemic had of late years invaded a large portion of the North West Provinces, and especially during and after the rainy season of 1873. That to this Epidemic the sickness which occured in the Canal districts was partly attributable, and in these Districts the disease was generally, though not universally more prevalent and severe than in other situations

2nd Fever in a greater degree than usual visited nearly every place in the North West Provinces, and in certain situations neither irrigated from the Canal nor within reach of its influence, fevers prevailed to an extent and with an intensity as great as in the worst Canal villages.

3rd Evils not necessary to Canal Irrigation, but to Irrigation impeded by bad drainage, natural drainage of the Country checked or interfered with, stiff and retentive soils, and natural disadvantages of site enhanced by excess of moisture.-

4th Considers that if Irigation was stopped within a Circle of five Miles round Military Stations, their Salubrity would not be affected, and that the Effects of Canal Irrigation are remarkably local.-

5th

5th Recommends certain conser-
=vative arrangements as beneficial
near villages, but questions whether
advice with regard to mode
of life, exposure &c would be
adopted and voluntarily prac-
-tised by the Agricultural
population.-

6th That the Eastern Jumna Canal
furnishes some of the best and
worst results of canal Irigation
Sickness where the drainage
has been obstructed, and
where the soil is clayey
as in the Centre Division
Health where the drainage is
perfect, and the soil is
light, as in the Northern
and Southern Divisions.

The result of the Committees
enquiry led, therefore, to the conclusion
that Salubrity depended in a great
measure on the nature of the soil
and the efficiency of the surface
drainage; it depended in fact on
the Irrigation from a canal being
properly regulated, and on the
canal itself being properly laid
out, so as not to interrupt the
drainage of the country.- With
reference to the Ganges Canal works
"we consider ourselves warranted"
say the Committee "in anticipating
"a far less amount of contingent
"evil than has been experienced on
"those of the Jumna, which were
"originally constructed without
"reference to many important points,
"which have been kept in view in
"projecting the present work, and
"more especially in drawing infer-
"=ences from results on the Delhi
"Canal great allowances should
be-

"be made for the natural dis-
"advantages of the Country through
"which it flows when compared
"with the Doab generally."-

With regard to its effects on the surrounding Country, the Ganges Canal had independently of the experience gained from the Jumna Canals ~~by its projectors~~, natural advantages of a very high order for securing the most perfect drainage; its course was on the watershed of the land lying between the ~~drainage into the~~ Ganges, and the Jumna Rivers; the beds of Rivers or the hollows of ravines were on its whole course ready to receive any cut that might be made for the relief of land lying in its ~~vicinity~~ vicinity; the whole of the works had been designed with reference to the most perfect system that could be devised for Effecting Irri-=gation with as little interruption as possible to the natural drainage of the Country, and by a judicious arrangement of Inlet and Escape to maintain an Equilibrium of water during the Monsoons, and during those periods in the Cold weather, when the Country was li-=able to inundation by partial although heavy falls of rain. The Jumna Canals, on the contrary, were in some respects most incon-=veniently lined out with reference to the drainage of the Country; the Hansi and a large portion of the Delhi Canal Especially: they had in their original construction been planned without any refer-=ence to those points upon which the Committee place such especial weight.- The System of Irrigation

although

although by no means deprived of the benefits of Rajbuhas was, to say the least of it, very imperfect, and ~~in some parts of the Delhi Canal where long Contracts had been taken~~, was occasionally of the worst possible description. It did not therefore, follow that the evils of the Junna Canals [irrigation] were to be perpetuated on a new line, where every attempt had been made to avoid them.—

The recommendations of the Committee with regard to the measures connected with the execution and management of the Ganges Canal works were judicious; they were summed up in the following terms, and were strongly urged upon the attention of the Government

1st That the Ganges Canal be kept as much as possible within soil—i.e. that its ordinary surface level should be below that of the Country.—

2do That Earth wanted to complete Embankments be never obtained from Excavations made outside of the Canal, except in such localities as will admit readily of drainage.

3do That the Canal and its branches be taken as much as possible along the Watershed of the Country, so as not to interfere with the drainage, and in all cases where such interference may be unavoidable, that the Executive Officer be instructed to provide otherwise for the drainage.—

4th That Masonry drains be constructed

=structed under Rajbuhas or Briage Ramps, whenever these cross the drainage of the Country

5th That no private water Courses be allowed, but that Irrigation be practised exclusively from Rajbuhas or main water Courses

6th That Irrigation be prohibited within 5 miles of a Military Station, and within One or two miles of large native Towns

7th That in clearing Embankments the Grass, weeds, &c, be not suf=fered to rot on the ground, but that they be burned as soon as possible after they are cut

8th That irrigation be altogether prohibited in localities which appear naturally to possess a Malarious Character.—

In concluding these rules the Committee observe that they are aware that their adoption will involve an expense not contemplated in the original Estimates for the work.—

The two main Questions therefore, upon which the further prosecution of the Ganges Canal works depended had been seriously discussed, and deliberately in=vestigated.— With the proper ap=plication of remedies as recom=mended by the Committee, the apprehensions ~~of~~ regarding the effects of Malaria on the health of the people, were not deemed by the Government of Sufficient Consideration to warant the relinquishment of the Project— Nor, although the difficulty of obtaining satisfactory Evidence on the Question of navigation was fully

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fully admitted, were the apprehensions entertained on that ~~Subject of~~ Subject originally to be Sufficient ~~weight~~ to justify any departure from the original scheme

The Supreme Government therefore in a despatch dated 1st May 1847, issued directions to the Agra Government to prosecute the work with the utmost diligence, on the principle that "the more vigorously "the work can now be prosecuted, "the cheaper it will be to the State"

From this period therefore the Government were fairly embarked in the undertaking; Major Baker was called upon to report on the best measures for carrying out the wishes of Government, and his attention was drawn to the following points, regarding the construction of the work which Government had finally determined on. —

1st The primary object of the Canal is to be Irrigation; Navigation is to be a secondary object, but is to be accomplished so far as may not be inconsistent with Irrigation. —

2nd The work is to be constructed in the most complete and substantial manner practicable. This includes the construction of all the works between Roorkee and the Ganges in the manner recommended in Major Cautleys last printed report of 1845 with any subsequent improvements and precautions suggested by Major Baker. The precise course of the Canal and its several branches below Roorkee is yet open for determination

3rd The precautions recommended by

by the Committee in their report of the 3rd March 1825 (of which I have before given a Copy) are to be adopted as far as may be practicable. - The first four of these suggestions must be borne in mind in the construction of the Canal. The last four will come into operation after the Canal has been opened and Irrigation commenced.

4th The available water power is to be employed as extensively as may be practicable for moving Machinery at suitable places for the erection of such Machinery; where there may be no immediate demand for it provision should be made for its future erection. -

5th In taking land for the Canal, arrangements are to be made for the formation of Reservoirs and plantations on the plan which has been adopted on the Ganna Canals

As the above rules are those upon which the work has been conducted, I have considered an introduction of them verbatim, as an interesting feature of my narrative; there was some discussion at this time on the subject of the more Southern districts, and of those which would derive the greatest benefit from the Canal, as these were questions, however, which depended on close Surveys of ~~Districts~~ Country, they will be more fully entered upon hereafter; it was evident however that my original Project ~~which was based on Surveys for~~ the Surveys for the

~~the~~

having been made for
the purpose of discovering the
watershed or backbone of the
Doab, and therefore conducted through
one line of country merely; were
insufficient for laying down a
branch lines, or of determining
through what districts such lines
might be most advantageously
carried. -

Major Baker's report was addressed to the Military Board, and dated the 13th of April 1827, the document is an exceedingly interesting one, and as it bears upon the whole of the Question, and defines the rules upon which the Executive Officers and others have been since guided in the progress of the work, an abstract of its contents will in this place be explanatory of the views that were then entertained on the subject

Major Baker's plan of operations was founded on the following considerations: -

1st That a very small portion of the Canal can be brought into use, before the Solani Aqueduct is completed. -

2nd That Earthwork in Channels and Embankments being liable to much injury from the weather, and consequently requiring extensive repairs, it is desirable that these should not be completed before the Masonry works

3rd That the whole project including both main and branch lines should be completed at once, both with a

a view of bringing the whole into Operation as soon as possible and to admit of a full supply of water being used, which could not be the case unless the branches were ready to receive their respective shares

The rapid completion of the Solani Aqueduct was a necessary desideratum under the above Con-=siderations; and it was proposed to concentrate all means upon this work, by which the object would be in all probability be gained in six years. The Calculations on which this was based were as follows:-

The Cubic contents of the Aqueduct being 8749524 Cubic feet; the following quantity of material would be required for its completion

Bricks 12"×6"×2⅔" for building } 69996192
Do Do for Sookee } 13474258

Lime in Cubic feet 962147
or in round numbers 10,00,000 Cubic feet of Lime and 850 Lakhs of Bricks.-

The work people required in pre-paring and using the material would be as follows:-

	Laborers
In brick making, inclusive of wood Cutting	3143333
In building Masonry and laying floors	781946
In pounding Sookee	64632
In undersinking the Blocks	31040
In the Earthwork of the aqueduct (inclusive of draught Cattle)	19772,750

Brick making to be completed in 5 years allowing 190 days in each year (deducting Sundays and rainy season) would require per diem 1149 Brick Moulders and 3309 Laborers.-

The

The remaining work to be completed in Six years, allowing 250 working days per annum, would require 204 Bricklayers and 2471 Laborers per diem. The workshops would require 50 Smiths, and 80 to 100 Carpenters per day; and an Establishment of about 1000 Bullocks, exclusive of Contract carriage, would be required for the Earth wagons and other purposes.-

To those who are unacquainted with the part of India in which the above works are situated, and with the system which the nature of the People and of the country itself, renders necessary in the Department of Public works; it may ~~be~~ be advisable to point out here that there are no contractors to ^ depended upon for the supply of Material. The Engineer as the Architect has to make his own Bricks, and to burn his own Lime; he has to purchase his supplies of Timber, and in many cases to proceed to the Forests himself to superintend its collection. He has in fact neither Contractors for making his Material, nor Contractors for putting that Material together; he is literally driven to his own resources, and although the Contract System in a limited sense is by no means misunderstood in these Provinces, it is confined to the Manufacture of material in small quantities, and to the Excavation of Earth, the latter being a trade which has long thrived both in the Punjab and in the more Southern States. In the case of the Earth ^ Contractor

Contractor must have originated in the great demand for Tank or Reservoir digging, which exists both amongst the Mussulman and Hindoo population, ~~or that to the demand~~ for water courses on the Canals for Irrigation. There are tribes, of a wandering class, whose chief if not entire occupation, is ~~devoted to Earth Excavation~~ digging Tanks and watercourses, and to these people we are indebted for the greater part of all our Canal Excavations. The respectable and wealthy class of Contractors which in Europe relieves the Engineer and the Architect from the detail of building, is unknown in the North Western Provinces of India; the difficulties therefore that ~~lay in the way of~~ were encountered by the ~~Projector~~ Director of the Ganges Canal works at the early period of their Establishment may be fully estimated.—

In continuing his Report Major Baker when referring to the Executive Establishment that would be ~~required~~ necessary, drew especial attention to the unusual quantity of Material that was required for the construction of the Solani Aqueduct, the position in which it was placed with reference to supplies; and the impracticability of ~~supplying~~ meeting our wants excepting by the exertions of our own Establishments; the appointment of an Officer expressly for the purpose of Superintending the Manufacture of Material for the Solani Aqueduct was recommended. This Officers duties ~~are~~ were to be ~~confined strictly~~ restricted to the Northern

Division

Division, to which a second Exec-
-utive Officer was to be appointed
for the Supervision of the works
Five other Executives were recom-
-mended for the works South of
Roorkee, their Divisional duties
being confined within certain
limits detailed in Major Baker's
Report.

It was proposed that the
whole of these Officers should as
early as possible after the close
of the rains of 1847, or in the
Month of November of that year,
employ themselves in obtaining
an accurate Survey of their res-
-pective Districts, and such a
Series of connected Cross levels, as
would enable them in consultation
with the Director of the works, to
fix on the best possible line for
the Canal: they would burn
bricks wherever fuel might ~~may~~ be avail-
-able along the probable course
of the Canal and in quantities
proportionate to the probable re-
-quirements. On the approval
of the line by the Director, it
would be carefully marked out,
and masonry bench marks es-
-tablished, and to use the words
of Major Baker's Report "The
"principal Masonry works
"would then be commenced, and
"a careful calculation having
"been made of the quantity
"of Excavation in the Channel
"and the time required for its
"execution, the ground would
"be taken up and the excava-
"tion be commenced with such
"reference to the progress of the

Solani

"Solani Aqueduct as would admit
"of the simultaneous completion
"of all the works."-

The extent of the Divisions which were thus told off to the dif=ferent Officers was arranged on the supposition that the 3rd Project which I had in my Re=port of 1845, recommended for adoption, would prove to be the most desirable; but before this could be determined on, accurate surveys of the Country were required: it was therefore proposed that the Director should personally visit the different Districts and in com=munication with the Civil Authorities determine the best and most favorable lines upon which Irrigation could be extended ~~with the greatest benefits~~; this de=termination would necessarily be based on the results of the dif=ferent Surveys and levels upon which the Executives were to be Engaged during the Cold Season of 1847-48 Regulated by the instructions conveyed in the Report of the Medical Committee.- In the meantime the progress of the works in the Northern Division, or in that portion between the Hills and Roorkee, especially that of the Main Works at the Canal Head and on the Solani River, would go on unimpeded, their positions having been accurately [illegible] determined in the earliest stage of the Project.-

The Establishments which Major Baker recommended was in accordance with that of my report; it gave to each Executive

the

the following aid independently of that of two assistants in his executive duties.-

English Office	Rs	a	p
1 English accountant	100	..	..
1 Do Writer	45	..	
1 Do Assistant &c	25		170 .. ..
Native Office			
1 Moonshee	30	..	..
1 Assistant Do	15	..	..
1 Native Surveyor	25	..	..
1 Native Doctor	15	..	..
2 Sowars @ 15 Rs each	30	..	..
1 Duffadar	6	..	..
4 Burkindauzes @ 4 Rs each	16	..	..
1 Chuprassie	6	..	
2 Do @ 5 Rs each	10	..	..
4 Classies @ 4 Rs each	16	..	.. 169 .. ..
Treasury			
1 Treasurer	20	..	..
1 Assistant Do	10	..	..
1 Jemadar	8	..	..
1 Duffadar	6	..	..
16 Burkindauzes @ 4 Rs each	64	..	.. 108 .. ..
Works			
1 Mistri Smith	25	..	..
1 do Carpenter	25	..	..
1 do Bricklayer	15	..	..
1 do Do	12	..	..
1 Jemadar of Chuprassies	8	..	..
10 Chuprassies @ 5 Rs each	50		135 .. ..
Per Month - Total Comprs Rs			582 .. ..

with permission to employ on detached works under Overseers:-

1 Mootsuddi @ 10 Rs per month
1 Chuprassi @ 5 Rs do

and a Guard proportionate to the stores and Treasure in his charge was also recommended

In reviewing the system of Accounts as practised in the Department of Public Works, Major Baker drew the attention of the Government

Government to certain points which appeared to him inapplicable to the expenditure on the large works of the Ganges Canal. Under the system now in force the Engineer in charge of the works keeps detailed accounts of expenditure, and on the completion of a work submits a Bill for audit, in which the actual rates of work are compared with those of the Estimate. If the Estimate be not exceeded, or the excess be satisfactorily explained, the Bill is passed, and the Executive Engineer is relieved of its amount.

Major Baker argued that if this system was observed in the Ganges Canal: the expenditure on the Solani Aqueduct, the Myapoor Regulator, the Dams, and principal works of the Northern Division, would not come under revision for many years, when the work would have passed through the hands of several Executive Officers, and when the money being spent, the check would be retrospective and inoperative: and that the amount of money at the personal risk of Executive Officers would accumulate before the completion of the works to an extent that would be felt as a grievous burthen, whilst the arrangement of complicated and long standing accounts would engross the time and energy which would be more profitably expended on the actual arrangements for work.

Major Baker therefore proposed for adoption a System which

which he considered more applicable to the Ganges Canal works, and as this System was approved of, and as far as possible was carried out afterwards, I shall give it here in Major Bakers own language.—

I. The works shall be executed agreeably to Major Cautley's designs, no deviation from which will be made by the Executive Officer without the sanction of the Director of the works, who will report the same to the Military Board.—

II When Money is required for the execution of work, applications will be made by the Executive Engineer through the Director to the Accountant North Western Provinces, who will issue an Assignment for the Amount.

III The Executive Engineers will send Monthly to the Director, detailed accounts of their Expenditure, viz^{t};—

1. List of Establishment
2. Account of work people employed and Materials expended in each work, and Measurements of work done
3. Quantity of Contract work and its cost.—
4. Amount of advances for Contract work—
5. Amount of advances for Materials
6. Quantities of Materials received
7. Do of Do expended

IV. The Executive Engineers Monthly accounts will be abstracted in the Director's Office, and after examination

examination will be forwarded for Audit to the Military Board accompanied by a Special report having reference to the following tests. –

1. The Regular Establishment charged will be compared with that authorized by Government
2. The Subordinate Establishment for the Supervision of work will be tested by the extent of work in progress. –
3. The work Expenditure will be tested by the extent of work done. –
4. The Number of Workpeople by the known amount of One Mans labor, their rates of pay by the ordinary rates of the District. –
5. The Quantity of Material used by what is known to be necessary for each description of work. –

V. On completion of any work the Director will draw out and submit to the Military Board a comparison of its actual cost with that Estimated. –

VI General accounts of Expenditure on the Canal works of all descriptions will be kept in the Directors Office, and Balance Sheets will be submitted to Government Quarterly or half Yearly as may be required

VII. To carry on the Plan as above detailed, An accountant with the requisite number of Assistants would be required in addition to the present Establishment of the Director's Office

Major Baker in Soliciting the

the favorable consideration of the Military Board to the above System of Accounts, observes that although it would involve a greatly increased amount of labor to the Director of the works, it would place in his hands a control over the Expenditure, and an insight into its details which under the existing System would be difficult of attainment, if not impossible, and that the labor and responsibility saved to the Executive Officers would be proportionately much greater than that entailed by the new System on the Director.—

Major Baker concludes this very interesting report, by pointing out, that to place the Establishments of Executives and Assistants on the footing which he has proposed, 7 Executives and 14 Assistants would be required— Of this number there were at the time 4 Executives and 4 Assistants available, leaving a deficit of 3 of the former and 10 of the latter; in the latter capacity Major Baker recommended the employment of 3 or 4 Sub Assistant Civil Engineers, or young Students from the Roorkee College, should so many be available— It was urged by Major Baker that nominations to these appointments should, as the period at which he was writing was unfavorable to Field work, be deferred until the Month of September, so as to admit of the work being set in active progress after the Cessation of the rainy season

Son

=Son.=

Major Baker accompanied this report by a Statement of the Expenditure which had been incurred on the Ganges Canal works up to the 30th April 1826. of which the following is an abstract

Northern Division						
Excavation	354525	5	6			
Masonry	19783	2	9			
Materials and Sundries including Establishment	219032	6	7	593340	14	10
2nd Division						
Excavation	93903	9	4			
Masonry	1267	4	..			
Materials and Sundries including Establishment	80296	10	6	175467	7	10
Director's Office Establishment &c				33894	6	5
Grand Total Expenditure up to the 30th April 1826. Cos Rs				802702	13	1

The suggestions and recommendations which had been made in the above Report, were entirely approved of by the Government in its letter of the 25th August 1827. ~~Entirely approved of by the Government~~. A Quarterly System of accounts, conforming in every other respect to that proposed by Major Baker, was however considered to be better than the Monthly one, and Rules to the following effect were laid down for future guidance

"In the Northern Division, the Executive Engineer of works will submit Quarterly to the Director a Bill for 3 Months work prepared in the usual departmental form i.e. Exhibiting Quantities, Rates, and Amounts, and accompanied by detailed Measurements of work done.

"The Materials used to be charged for

for on the rates furnished by the Executive Officer of Materials

"When the rates of work differ from the Estimated rates, full explanation to be given at the foot of the Bills in the usual manner.-

"The Bills after careful examination by the Director, will be submitted with his remarks to the Military Board.-

"The Executive Officer whose duty it will be to collect and prepare Materials, and to take charge of Bullocks, Carts, &c., will submit quarterly to the Director for transmission to the Military Board, a detailed statement of expenditure and results on each item of his charge, including Carts and Bullocks, accompanied by such explanations as may appear to be necessary.-

"To the above Statement will be appended a Balance Sheet shewing on One side the actual expenditure on each item, and on the other the amounts received from the Executive Engineer of Works and the Stock in hand.-

"He will also submit a list, deduced from the above mentioned accounts, of prices of Materials, Bullock hire &c., which he proposes to charge during the ensuing Quarter, to the Executive Engineer, to whom it will be communicated by the Director if approved.-

"The Executive Officer of Materials will get advances from the Executive Engineer of Works, and will write off per Contra, the value

of

of Materials supplied—

"In the smaller Divisions it may be expedient from motives of economy to unite in One Office the functions of the two allowed for the 1st Division.—

"The Executive Engineer of a smaller Division will, therefore, keep and submit Quarterly to the Director distinct accounts of works and Materials as laid down for the 2 Officers of the 1st Division.—

"On completion of any work extending through more than one Quarter, the Director will draw out and submit to the Military Board, a comparison of its actual Cost with that Estimated, at the same time reporting on the Quality of work, &c.

Every work commenced and completed during the Quarter will, by the Director be separately reported on, as to its quality, &c.—

"General accounts of Expenditure on the Canal works of all descriptions will be kept in the Directors Office, and Balance Sheets will be submitted to Government, Quarterly or Half Yearly as may be required."

In providing Major Baker with the above rules, he was told that if he "considered it necessary to increase the strength of his own Office Establishment in order to conduct this new System of Accounts with punctuality and efficiency, he was authorized to entertain an Accountant on a Salary not exceeding 300 Rupees pr Month, and 2 Assistants on a Salary not exceeding 100 Rupees each pr Month."—

The

The forms of Accounts and papers which were submitted on the above System will be found in the Volume of Tables, ~~and I have in that as the most appropriate place, added certain remarks on the System in general, and the working results during its progress under my management~~

On the 1st of October 1847, a series of Instructions were circulated to Executive Officers on their proceeding to commence field work, to Examine the Country as before explained, and to determine the best line upon which the Canal and its branches should be carried, a Copy of these Instructions will be found in the Volume of Tables. In the meantime ~~the progress of~~ the different works in the Northern and in the early part of the 2nd Division in the Mozufurnuggur District were proceeding with all the vigor that additional means had instilled into the Establishment, and at the period when I rejoined ~~the works~~ early in January 1848, I found everything prepared both in Money and Establishment for carrying on the works with the utmost Energy —

Chapter III

Trial period under the Directorship of Lt. Col. P. T. Cautley From 1848 to 1854

Major Baker delivered over charge of the works to me on the 11th January 1848, with the necessary Memoranda as to progress

progress and expenditure, and it may be interesting here to place upon record the State of the works at this period, as well as the amount of money that had been expended upon them.-

I have in the Volume (appendix E) of Tables and appendices, given in full the Report on the State of the Ganges Canal works at or about the period when Major Baker delivered over charge to me;- the introduction of this paper in its fullest details is necessary to shew the progress that had been made up to this period, together with Major Baker's views on points ~~as regards~~ connected with the general project.- I may observe however, that independently of the Block foundations, and of the side Revetments to the Solani Aqueduct which had been commenced, very considerable ~~progress~~ advance had been made in the works at the Myapoor Dam- The Regulating Bridge at that point, together with the Bridges for cross communication at Kun-khul, Jorwalapoor, Munglour and Joghulpoor, were in an advanced State, the Arches and superstructure of the Myapoor Regulator being very nearly completed.- The foundations of the Bithur Falls had been commenced upon.- Numerous Chokiebuild-ings had been finished, and Excavation was either in progress or had been completed from the 1st to the 10th Mile of the course of the Canal.-

On the 31st December 1847, the

the state of the Expenditure was as follows.—

Northern Division						
Excavation	476190	..	..			
Masonry	257878	..	..			
Materials and Sundries including Establishment	433228	..	..	1167296	..	..
Mungloor or 2nd Division						
Excavation	302900	12	4			
Masonry	25823	5	3			
Materials and Sundries including Establishment	127914	1	4	456638	2	11
3rd, 4th & 6th Divisions						
Preliminary Surveys, Establishments &c —	..	..	..	5539	10	11
Directors Office Establishment &c	.	.	..	72555	10	7
Grand Total Expenditure on the 31st December 1817. —				1702039	8	5

(Continued Page 113)

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99 on to Page 113

Major Baker's plans having determined him to leave the works in December, I ~~left~~ quitted England at the end of August 1817, for the purpose of reassuming the duties that I had left 3 Years before, and of relieving Major Baker from a charge, which had by the most judicious management on his part, and by the best tact in the organization, become one of comparative ease and simplicity. My object in leaving England at such an early period was to visit the Canals in Lombardy and Piedmont, and make myself acquainted with the Method of Embanking, and the works connected with the Regulation of the course of Rivers for which the Italians have been long celebrated: To do this my time was limited to the Space of about Six weeks, but during that period I inspected the

Head

Heads and other works on all the
Canals in the neighborhood of
Milan, examining in detail the
~~course~~ of the Ticino River ~~from its de-~~
~~parture~~ from Sesto Calende
to the Mouth and along the line of
the Naviglio Grande to the Town of
Buffalora, ~~as well as~~ I visited also the Locks
and other interesting works for navi-
gation on the Pavia Canal. In
Lombardy ~~generally~~, I saw for the
first time the (Fontanili) method
of collecting water for Irrigation
by tapping Springs, and by these
means providing Irrigation for
considerable tracts of Country.
The Milanese Module for regulating
the discharge from the Canals,
and the Meadow (Marcite) Ir-
-rigation with all the attention
which that System necessitates
in levelling and equalizing the
Surface, were Objects of peculiar
interest; I inspected also some
very interesting and successful
works although on a small scale,
for the riddance of Silt from a
Canal in the neighborhood of
Bergamo; and in the vicinity
of Mantua and Cremona,
became acquainted with the
bunds and works of that description
for which the River Po is celebrated.

In Piedmont the Canals
from the Dora baltea, and their
Heads in the neighborhood of
Ivrea, were inspected in great de-
-tail, as although the Canals them-
-selves carried comparatively to
those in the North West Provinces of
India

India small volumes of water, they were connected with mountain Rivers subjected to violent floods, and therefore liable, ~~although in a less degree~~, to evils similar to those with which we have to contend. The works over the Po connected with the Genoa Railroad, situated near ~~Castelmaro~~ Mongalieri, as well as the Bridges (then building) or built over the numerous tributaries which cross the high road between the Ticino River and Turin were all of them subjects of great interest. At the time that I visited Turin a Masonry Bridge over the Stura River was in progress of construction, the River at the point where the Bridge was ~~building~~ being built took a considerable curve at which a wooden Bridge kept up the line of communication; the Engineer had fixed the site of his Masonry Bridge on the chord of which this curve was the arc. the Bridge in fact was being built on dry land, and under circumstances precisely similar to those which we are constantly in the habit of adopting in these Provinces: the proposed design for making a ~~straight the River~~ cut to deliver the Stream upon the Bridge, and the system of Bunds and Spurs on the upstream side of the works, for the purpose of regulating the River in its new course ~~upon the Bridge~~, were observed by me with much attention. The character of the Stura River at the point in question ~~being~~ was exactly that

that of the mountain Torrents / or Raos as they call them in the North western Provinces / at the foot of the Sewalik Hills, a wide straggling shingly bed, depressed below the surface of the country to a very moderate degree, fringed and scattered over with long grass, and from its appearance running on a considerable declivity. A Set of plans descriptive of the whole of the operations, was purchased by me from the Office of the Board of Works at Turin for our Ganges Canal Library, and as I consider these plans to be admirable descriptive of the system of bunds and spurs adopted by the Italian Engineers for regulating and directing the Course of Rivers, I would recommend them to the Department of Instruction for ~~the use of this Institution~~ the Civil Engineer's College at Roorkee. With the exception of some Canal works in the neighborhood and to the North of the Town of Novara, and to the works for Hydraulic instruction near Turin, I saw nothing further in Piedmont, but I regretted exceedingly that the limited time that I had at my disposal prevented me from making a further stay amongst works from which I had already gained a great deal of valuable information, and from the Engineers of which the information which I required was imparted with the utmost Esprit and liberality. Should my friend M. Carlo Noe, the Inspector

of

of Canals on the Doab Baltea
ever cast his eye on these pages,
I trust that he will accept the
expressions which I now make
as a small return for the time
and trouble which he as a perfect
stranger, and without ~~any~~ my having any
introduction to him, so kindly devoted
to my service. -

Captain Baird Smith who
two years after my visit was de-
=puted by the Honorable the Court
of Directors of the East India Com-
=pany to Lombardy and Piedmont,
for the purpose of reporting
on the works for Irrigation in
those provinces, has in his two
admirable and instructive volumes
entered so fully into the subject,
especially into that in which
the fiscal and Legislative manage
=ment are concerned, that the few
remarks which, before dropping
the subject, appear to me to be
in this place necessary, must
be confined to the impressions
that my mind received on visi=
=ting works the reputation of which
had been for so long a time familiar
to me. - With regard to the Canals
in Lombardy I confess that I was
disappointed, this disappointment
however did not arise from the
works themselves from which I
not only derived great instruction,
but a number of useful hints
from which I have largely bene=
=fitted in designing the Ganges
Canal works; but from the pe=
=culiarity of their position, and
if not their entire freedom from
the effects of mountain Torrents,
their connection with themselves

such

such peculiar circumstances, that the effect of their contact, which is a source of such difficulty and danger on the canals in the North west Provinces of India, is almost entirely neutralized

The Ticino and Adda from whence the great Milanese Canals to which I have before referred, derive their supply, have their sources in the large Lakes which lie at the foot of the Alps to the North of Milan; the Lago Maggiore in the case of the Ticino, in the case of the Adda, the Lago de Como. The torrents which during the rainy months come down from the mountains with equal force both in Italy and India, are in the former case received into the bosom of the great Lakes, where they exhaust themselves over very extended surfaces before the effects of the influx of water can be felt by the Canals; in the latter, they cross the lines of Canals with violence unmitigated by any intervening circumstance" It is scarcely "possible" as Captain Baird Smith observes when adverting to these large Lakes and the influence that they exert on the Canals in Lombardy "to overestimate the "value of this natural ~~Canal~~ arrangement. "it is one for which Lombardy "has constant cause to be grateful to a Skill above that of "Man, and looking to the natural features of the Country it

"it is perhaps not too much
"to say that without it the
"Rivers flowing directly from the
"Mountains would as often leave
"blighted the land by their des-
"tructive floods, as ~~blessed~~ blessed it
"by the discharge of their fertiliz
"-ing waters"

~~With an almost total relief~~ Being then almost entirely relieved ~~therefrom~~ from the effects of Mountain torrents, ~~and with an entire re-~~ ~~-lief from those evils~~ in crossing their alignment, with an admitted superiority of soil which is high-ly beneficial to the beds of the Canals, and affords the greatest stability for foundations; and with the finest material in the world perhaps - viz^o. the Granite from the Bavino Quarries from which to build ~~his~~ the works, the Lombardest Engineer is placed in the opposite extreme to his brother Engineer of India, who without the slightest exaggeration has to deal with the Mountain Torrent in all its deformity, with illimitable depths of Sand, and with difficulties in procuring Material ~~to a degree that~~ such as would hardly be credited ~~by those of Lombardy~~ without personal experience of them

There were very striking features in the working of these Canals, however, that could not escape my notice, and perhaps the most remarkable one, was the use of the simplest means and the simplest expedients in all cases where regulating supply was necessary; the simplicity of the means in raising ~~the~~ their Sluice Gates.

For

for relieving and filling their Lock Chambers - for fixing the gates of their Locks, and for breaking the face of Currents by Piles, were mat- =ters of very great interest to me, and the interest was enhanced by observing that this simplicity of means had its desired end, ~~and that the result was~~ in producing real ef- =ficiency. -

It may be observed however that the variation in surface of these Canals during the year is not more than 12 or 18 English Inches, that this freedom from floods and overcharges of water arising from the circumstances above described in their connection with the Lakes gives them a security which no Canal in the North West Provinces of India can hope to enjoy: ~~and it leads to the circumstance which is at once very remarkably illus- =trative of the immunity that these Canals hold from inundations, that works for regulating the sup- =ply into the Canal Heads are not considered necessary.~~

The most noteworthy consequence of this limitation of surface variation is that no works for regulating the supply at the Canal heads are con- =sidered necessary: a fact itself strikingly illustrative of the immunity from floods enjoyed by these Canals.

The Canal works of Lombardy therefore, were to me wanting in the main point to which my views were directed; the River works however, were full of interest, and I found with regret that the intention that I had started with, of visiting the Po in the neighborhood of Ferrara and the Adriatic was frustrated by the necessity of my having to reach Trieste in time to join the Steamer that was to carry me to Egypt

and

and ultimately to India. -

The canals which I visited in Piedmont were taken off from the Dora Baltea a Mountain River which during the Cold weather is subject to floods of a very violent description; the Canals themselves are, compared to those in the North west Provinces, small, they are not used for navigation, and are regulated at their heads by a series of small Sluices worked by hand Spikes; the Sluices themselves being arranged in a covered Bridge which crosses the Canal head, and which entirely precludes all possibility of danger from sudden rises in the Surface of the River, and ~~entirely precludes~~ prevents the passage of boats. -

The ~~means by which the~~ water is taken from the River and directed to the mouth of the Canal ~~are~~ here as in Lombardy ~~obtained~~ by a Masonry Weir unbroken in its whole length excepting at ~~one~~ one point through which the Surplus water escapes with great violence; between this Weir and the Regulator are Sluices ~~entirely~~ detached from the Weir, for the purpose of passing off Surplus water into the bed of the River and by these means, regulating the Canal supply. - In Lombardy precisely the same plan is adopted, and in the case of the Muzza Canal, the Weir extends completely over the bed of the River, and

the

the regulating sluices which are situated between the head and the Bridge of communication for the Railroad, are of the same description and on the same principle as those used in Piedmont. Within the ~~late~~ last few years before I visited the works in 1847, it had been found convenient on the Muzza Canal to multiply the number of these Escapes. This system of detached sluices in the position which I have above described is much approved of by the Italian Engineers, as independently of giving a ready Escape for surplus water, they provide a scour, and thereby the means of getting rid of the silt and deposits which invariably establish themselves in the Mouth of the Canal

On the Lombardy canals and under the advantages with which their water reaches the canal heads, the Elevation of the Sills of the weirs does not appear to be of serious consequence in raising the beds of ~~the~~ the Rivers on the upStream side: In Piedmont on the contrary where the weirs are built over Rivers directly running from the mountains, the effects of deposits above the weir as might have been expected are of a very serious nature; at the time that I visited Ivrea and the head of the Ivrea Canal, this evil ~~of silt deposit~~ appeared to me to have reached a maximum, and large parties of Laborers

Laborers were employed in the water in removing the ~~deposits~~ sand & gravel and clearing an open channel in the direction of the Canal Head. It has been found expedient in the Canalworks in the North West Provinces of India to avoid as much as possible any elevation of Sill to the Masonry Dams which cross the Rivers at the heads of canals; these Dams are in fact a line of Sluices with Gates or Shutters which are capable of being entirely laid open down to the bed of the River during the period of floods, ~~and~~ In rapidly rising Rivers like those in India the method which has been adopted by our Engineers is, I believe, the most appropriate; in some cases perhaps it might be modified with advantage, where the head supply for the Canal must necessarily be raised to a considerable height above the Dam flooring, as in the case of the Myapoor works at the head of the Ganges Canal, ~~but the necessity of modification shows itself more in the value to be derived from the reduction of extent of Sluice Openings, with the increased facilities for relieving these Openings during floods, than from any particular advantage in the maintenance of Supply.~~

but in such cases, the advantages of modification would be found in increased facilities of management during floods due to the diminish'd area of sluice surface rather than in any particular benefit in the maintenance of supply.

As far as my travels extended in Piedmont I looked in vain for examples of Canals crossed by Mountain Torents after their departure from the source of supply with the exception of a case North of Novara where the Agogna River is passed by a Masonry Channel

carried

carried under it, or by a "Salto di "Gatto" /a Cats leap/ as the Italian Engineers call it, I saw nothing approaching to the great evil to which renders our Canal Engineering in India a matter of such serious difficulty. The Mora Canal which crossed the above mentioned River was a mere water course and would have come under the denomination of a 1st Class Rajbaha in the North West provinces; whilst the bed of the Agogna under which it passed did not exceed 150 feet in width. The River at the point where the Mora crosses it has a well defined deep section, with a shingly bed nearly dry at the period of my visit in October, and is crossed by a Bridge of 3 Arches at a distance of about 100 feet above the line of Canal.—

I cannot leave the subject of these Italian Canals and their works, without an expression of surprize mixed with a good deal of satisfaction, at the numerous instances in which we who were entirely separated from all communication with the Italian Engineers had, by the mere process of simple reason, arrived so frequently at precisely the same results, and in so many cases had adopted the same expedients; this is remarkably shewn in the protection given to the Aprons and tails of their Weirs. When standing on the Weir at Porea I could have imagined that I had before me the works of our native Establishment in India; in all

their

their temporary bunds, Spurs, and flank protections to Cuttings; the devices for making them useful and efficient, are very much the same in both countries; and the feeling that exists amongst the Italian Engineers of introducing the utmost simplicity into their works, so that the Establishment which consists generally of village people may perfectly comprehend the ways and means to which Machinery may be applied, accords peculiarly with the experience that we have gained in our dealings with the same class of people who have the charge and supervision of detached works on our canals. The system of Retaining Dams, or Bars constructed across the bed of a River for the purpose of holding up the bed to a fixed level, ~~and~~ which appears to be practised universally both in Lombardy and Piedmont, is another example of expedients being devised by simple inductive reasoning, without the parties having any connection or communication with each other. The Retaining Dams on the Muskuna and Nogong Rivers, two of the mountain Torrents which cross the line of the Eastern Jumna Canal, have their representatives on the Po at Turin, on the Serio River at the village of Albino near Bergamo, and on a River from whence a supply for Mills (and on which the Hydraulic Establishment is situated) is taken near Turin. In the latter case the Retaining Dam is placed at some distance below ~~close to~~ a weir

made

made of timber and shingle which is thrown across the bed of the River for the purpose of turning water into the Canal; and the retrogression of levels upon which, led to the necessity of its being protected, the work that has been built ~~construction, no appearance of~~ for its protection is ~~no~~ similar in every respect to the retaining Dam used ~~this work closely resembled those~~ in the North West Provinces. In the other places to which I have alluded the retaining Dams are built on the downstream side of Bridges, and with the intention I presume, of protecting those works from the effect of retrogression.

I have ~~many~~ remarked, on the Piedmont Canals that the immediate connection of their heads with Mountain Rivers, renders them in some degree liable to the dangers from inundation and accident to which the Canals in these Provinces are subjected. The circumstance of their being very much smaller however; of their not being available for Navigation; of their heads being protected and crossed by a bar of Masonry pierced with small and easily worked sluices for the admission of water. and of their not being crossed by lines of Mountain Torrent, place them so far as difficulty of management is concerned on a scale inferior to the Canals for Irrigation in the North West Provinces of India. —

~~During~~ In my progress through Egypt I visited the works at the Head of the Delta of the Nile, which were at that time under construction on the designs of a French Engineer, with the Egyptian cognomen of Mousul Beg

Bely, ~~and which I may observe in passing in the form of a Dam~~ ~~a Bridge~~ these works (Barrage) independently of Toll are intended to maintain the River at the point where the Rosetta and Damietta branches separate, on levels appropriate to the supply of 3 Canals which are ~~intended~~ to be taken from it

regretted that my time was too short to admit of an examination of the numerous works for Irrigation that are connected with the Nile; with many of which I came in contact in the neighbourhood of the Barrage and Cairo.

The works for, and the system of Irrigation practised in the Land of the Ptolemies ought to be the subject of deliberate history.

End of Note.

On the 14th December 1847, I reached Bombay, and on the 11th January following (as stated at the beginning of this Chapter) I resumed charge of the Ganges Canal works from Major Baker, having in the few previous months, travelled over some of the finest fields of Artificial Irrigation in Europe, and having derived as much benefit as I could from the inspection of numerous works devoted to the peculiar object on which my time was hereafter to be occupied.—

(Continued from Page 99)

The Staff which was attached to the works ~~at this period~~, and the duties upon which I found them engaged on my return to Office in 1848 were thus:—

In the Northern Division which extended from the Head at Hurdwar to a point 4½ Miles below Roorkee, Lieutenant W. Yule (who in the Month of April following was succeeded by Lieutenant A.G. Goodwyn) the Executive Engineer in charge of the works had under his orders.—

Lieutenant Price of the 1st Bengal Fusiliers
Mr Lokay
Mr T. Login } Uncovenanted
Mr J. Parker }

the

the works in progress were general throughout the Division - Sergeant Finn, a Canal Officer of great experience being in charge of the material Department, of which he had shortly before assumed the direction charge. -

In the 2nd Division which extended to the 110th mile running through portions of the Saharunpoor Muzaffurnugger and Meerut Districts, Lieutenant Fraser of the Engineers, who was the Officer in Executive charge, had under him as assistants

Lieut Dempster of the Bengal artillery & Mr F Read - Uncovenanted -

Excavation had been in progress in this Division from the earlier periods of the operations, and before I left India: at the time of my rejoining the works, considerable advancement had been made, and parties were excavating as far South as the 50th Mile; The collection of Bricks and other Material was collecting was in active progress throughout the whole of the Division, and in the more northern parts some of the masonry works had been commenced pushed on; - the Mungloor and Doaba Bridges having been completed up to the Spring of the Arches. -

In the 3rd Division, Mr Volk who had been appointed Executive Officer for the Superintendence of the works with Lieut Merrick of the 3rd N. I., and Lieutenant Newmarch of the Bengal Engineers, as his assistants were engaged in Surveys and levels of the Country and were

collecting

collecting the necessary data for laying down the main line of the Canal. This Division extended through portions of the Bolundshuhur and Allygurh Districts as far South as the Town of Koel.

The 4th Division had been placed under charge of Lieutenant Rodgson of the Bengal Engineers; This Officer with Lieut Dumbleton of the 10th Cavalry, as his assistant, was employed on the Surveys and Levels of the country lying through the Allygurh and Mynpoorie Districts.

The 5th Division which consisted of the line of country on which it was proposed to carry the Etawa Branch, was unoccupied

The 6th Division was held by Lieut Charles Hutchinson of the Engineers, with Lieut Burne of the 18th Regt. of N. I. These Officers were ~~employed~~ engaged on the Surveys of the Country in the Furruckabad and Cawnpoor Districts, in extension of the line occupied by Lieut Rodgson.

In addition to the above Officers who were strictly attached to the Divisions, Mr Dodsworth a Surveyor was engaged in carrying on a series of Longitudinal and cross Sections on the line of country between the Rinde and the Jumna River for the purpose of determining the best line of direction for the Etawah Branch, or that which had been fixed upon as the 5th Division.

It will be understood therefore that at the period to which

I am referring, Excavation and Masonry works were in progress from the Canal Head to the 50th Mile of its course; beyond that point, the Surveys and levels of the country upon which the direction of the Canal had to be determined were still in embryo.

The works at this time had been proceeding on the plan laid down in the 3rd project which I had submitted to Government previously to my departure for England in 1842, ~~Neither this nor any of the others which I had suggested for the consideration of Government, varied either in direction or in works on the first hundred Miles, but beyond this point~~ Opinions were very much divided as to the line which would be best adapted for agricultural ~~purposes~~ meeting the wants of the community, and my attention was directed to the following views which were entertained by the Agra Government on the Subject of its extension.—

"The course of the Canal be-
"low Roorkee or rather from the
"point in the Muzuffurnuggur
"District whence the Futtiguh
"Branch will be thrown off, re-
"quires mature consideration. The
"primary object of the Canal is
"to be Irrigation and it is very
"doubtful whether the course
"which follows the water shed
"line down to Allahabad is that
"which most needs a supply
"of water for Agricultural pur-
"poses.— The Kalli Nuddi, the
"Eesun, the Pandoo, the Runde,
"the Seyngoor, and the Kunnaon

each

All the projects suggested by me for the consideration of Govt had their works and direction in common for the first hundred miles but beyond that Distance

"each have their rise in the plain
"of the Doab south of Roorkee, and
"after running for some time in
"a direction nearly parallel
"with either the Ganges or the
"Jumna, empty themselves into
"One or the Other - They thus divide
"the Doab into several longitudinal
"sections, the present state and
"actual capabilities of which are
"very different."—

"This is peculiarly the case
"in the District of Cawnpoor
"which stretches across the Doab
"from the Ganges to the Jumna, and
"through the centre of which inter-
"mediate between the two Rivers,
"the Rinde pursues its course
"In the Jugumnas (Division
of a District) between the Rinde
"and the Ganges, water is near
"the surface, wells are consequently
"numerous, and the country is
"rich and well cultivated. —
"Between the Rinde and the Jumna
"water is far from the surface and
"wells are constructed with diffi-
"culty, the Country is exceedingly
"ill cultivated and poor. - There
"can be little doubt that a
"Canal for Irrigation is more
"wanted in the latter than in the
"former, and yet the plan as
"originally laid out contemplated
"throwing the largest supply
"of water into the former". -

"These circumstances regard
"ing the Cawnpoor District are
"mentioned as illustrative of
"the considerations which may
"influence the Course of the Canal,
"but are not to be considered
"as at all affecting the final de
"-ter-

"termination which may be reached
"after the Country has been examined
"and reported on by competent Offices"

The Surveys and Levels upon which the Projects which I had up to this period submitted to Govern=ment had been based, consisted merely of the examination of the tract of Country which might be considered the line of water shed between the great Rivers. the whole of the work with the exception of 2 or 3 cross levels which were taken in the Futtipoor District, had been done by myself unaided by staff of any des=cription; the only lines therefore that had undergone the test of positive Survey were those from Burdwan to Allahabad, with a Branch line to the Ganges at Cawnpoor; the Country towards the Jumna had not been examined, the Sketch that I had given of it was necessarily a general one, and ~~the~~ an evident necessity ~~that~~ therefore existed of subjecting the Country that would come ~~came~~ under the influence of the Canal whether on its main line, or in its branches to a more detailed and comprehensive examination than I had been able to bestow upon it, ~~were questions evidently to be con=sidered~~ previously to the de=termination of the precise direct=ion to be given to the lines ~~on which the Canal might be most advantageously carried~~.

There were also other questions which ~~it~~ immediately occupied my attention. To carry into effect ~~as that which has~~ the sanatory measures recommended in the ~~been above alluded to.~~ The

Report

Report of the Medical Committee ~~and its injunctions on Sanatory points~~, although ~~in no great degree affecting~~ the plan of Excavation which had been proposed for the main line and its branches, was in no great degree affected thereby, yet required ~~let to~~ consideration on the best methods ~~to be adopted~~ for supply-ing the Irrigation Channels and for placing their heads in a position the best ~~to determining in what way~~ adapted to the works; it was ~~the heads of these Channels could be most conveniently adapted to~~ further necessary to determine some deliberately the ~~works. A more deliberate enquiry as to the~~ position and number of Escapes as well as the means for regulating the water in its connection with the Branches; and these various measures clearly ~~was connected with Sanatory measures and~~ depended a good deal on the results of the detailed surveys.-

The Channel Excavation which, as I have before stated, had been steadily in progress from the first commencement of our operations, ~~limited by the means that were placed at our disposal~~, had advanced far down the high land South of Roorkee; The results of ~~as far as~~ this Excavation so far as it had been carried, ~~had been carried, the results~~ had exhibited throughout a ~~been as regards~~ character of an exceedingly unsatisfactory soil. The Clay subsoil which had been observed in a greater or less degree to be a characteristic feature of the country, was ~~turned out to be a~~ merely superficial ~~stratum~~ varying in depth from 3 to 10 feet, and overlying a de-posit of (in many cases) purely River Sand, extending apparently to an unlimited depth.- The

Excavation

Excavation which had up to this period been made had in fact removed the whole of the good, leaving the Sandy Substratum for the bed of the Canal.- As further Enquiry and examination by excavations carried on in the more Southern districts exhibited results equally unfavorable, My attention was directed to the inapplicability not only of the Slopes of the Canal bed as originally projected, but to the design of the works generally, which with reference to their foundations, and to the means provided for their protection, were clearly inadequate to the contingencies arising from these unexpected ~~difficulties~~ results of the Excavations.-

The points above noticed were brought under review at the earliest period possible, and the Surveys and levels of the Country in the Southern Districts having been completed, and the direction of the Main line and its branches having been determined ~~as~~, the whole of the works of the Main Line was in progress during the Cold Season of 1849/50.-

In 1850, at the desire of the Agra Government, I submitted a report with a revised Estimate founded on data derived from 2½ years experience of the Cost of Labor and Materials of the different districts - and shewing the actual Amount of Expenditure which ~~under the Provisions of the~~ in providing for the contingencies ~~Resolutions~~ above referred to, would be required to complete the works

The lining out of the ~~Canals~~ Channel had

had at this period been devised ~~to as the~~ best ~~method for conveying~~ to compromise the water, and to deliver it over these Southern Districts, where from the difficulty in sinking wells and from the depth at which Spring water was found, its uses would be the most appreciated, and its benefits would be the most palpable.—

The Main Trunk was carried in the direction proposed in the original Estimates as far South as the 180½ Mile; throwing off from the left a branch to ~~the~~ Futtiguh, and to the right a branch to the Bolundshuhur or Tuppul Districts; the former leaving the main line at the 50th Mile and the latter at the 110½ Mile: between the 110th and 180½ Mile and intermediately between the latter two points, another branch not included in the original Estimates had been projected for the irrigation of the Country lying to the left of the ~~Ganges~~ Kanoor River and to the Right of the town of Koel; this Branch which left the main line on its right bank was intended to irrigate a tract of Country equal in extent to that of the Bolundshuhur Branch

At the 180th Mile, or at a point a few Miles below the Town of Koel, the main line is divided into two Canals or branches of nearly equal dimensions; the One on the left bearing directly upon Cawnpoor the Ganges River at ~~and the Ganges River at that point~~, and the other upon the Jumna at a point near

near the boundary of the Futtiapoor and Cawnpoor Districts; the latter keeping to the right instead of to the left of the Runde River as was originally contemplated, and passing through the Districts lying on the Dumna side of the Doab. This arrangement ~~which~~ was consonant to the views ex-pressed by the Government, and better adapted to the economical application of the water for the purposes of Irrigation.-

In submitting my Estimate of 1830 ~~to the Government~~ it was prefaced by the following observations

"There are three points which have "greatly influenced the designs "of the works now estimated for viz^{t}.

1st The results of the proceedings of a medical committee, which deter-mined that the high water of the Canal should be kept as much as possible below the surface of the Country.-

2nd The results of Excavations in the upper Divisions shewing that the subsoil only was clay, with an uninterrupted sub-stratum of Sand.-

3^{d} The Change of design in the distribution of the supply below the 110th mile, which in connection with the results above referred to, have in fact led, with few exceptions to the total reno-vation not only of the masonry works, but of the capacity of the Canal Channel.-

"In referring therefore to the papers already

=already printed= I observed "that
"the present may rather be con-
"sidered a 4th in succession to
"the 3 projects formerly submitted
"than a Revised Estimate on what
"has gone before" —

As the alterations arising
from the above considerations neces-
=sarily added largely to the amount
of Estimate, it will be satisfactory
in this place, without entering
into the particular detail of each
work which will be fully describes
hereafter, to give a general outline
of the Changes which were proposed
and of the effects that such Changes
had on the different divisions

The 1st Division, as I have
before explained, includes the
whole of the works in the Khadir
or low land of the Ganges, and
extends to a point on the high
land of the Doab about 1½ Miles
distant from the Town of Roorkee
with the exception of a more di-
=rect bearing upon the Rutmoo
Torrent from that of the Rampoor
the direction of the Canal align
=ment in this Division was in
close approximation to that of
the original design. The works
on the early part of its course
as well as those on the Solani
Torrent were with the addition
of improvements arising from
local circumstances also similar
intermediately, however, between
the Town of Dowallapoor and
the Peran Kulleen ridge, great
modifications had been made, not
only in the slopes and capacity
of the excavated Channel, but also
in

in the design of the Masonry Works.
It had been found necessary to
carry the deep digging to points
much further back than was orig=
=inally intended, to enable the
floods of the Ranipoor and Puttri
Torents to pass over and run in=
=dependently of the Canal Chan=
=nel, an arrangement which
the enormous quantity of Silt
brought down by these Rivers
appeared to render indispensable
The greater part of this excess of
digging had to be performed
under great difficulties arising
from the height of Spring water,
with the necessity of providing
against the inroads of floods,
during the progress of Excavation:
the Soil was of such a light des=
=cription that foundations for
the Masonry works of a charac=
=ter not before contemplated, either
in Massiveness or depth, became
a necessary part of the Estimate.
The more direct bearing on the
Rutmoo Torent, and a general
consideration of the action of
water upon a bend of greater or
less radius, together with more
deliberate observations upon the
Torent itself, led to a complete
remodelling of the works opposed
to this River: Masonry Revetments
were projected upon the Curve
of approach, and the foundations
of the whole were designed of
a much more massive descrip
=tion than those originally esti=
=mated for ~~contemplated~~. The works on the
Solani Valley were with the
exception of Terminal Cuttle

Ghats

Shafts and a Bridge at the North to correspond with that of the South End, unaltered in Elevation; the foundations and floorings of the Masonry Aqueduct had been strengthened, and in consequence of Kunkur not having been found in sufficient abundance, the use of Brick had been more generally practised.-

With the exception of the first 2 Miles of its course, the slopes of the Canal bed had been revised and modified;- superfluous slope had been disposed of at the Masonry Falls, and an additional fall of 8 feet had been designed at the extreme end of the Division near the village of Assupnuggur. Below Assupnuggur and as far South as the 180th Mile the slopes of the Canal bed had been reduced from 18 to 15 Inches per Mile, the superfluous slope having been disposed of in additional Masonry descents or Falls of 8 feet in perpendicular height each, as far South as the 105th Mile, and beyond that to the 180th mile point by Two falls of 5 feet each. The Sandy nature of the Soil, especially on the line extending from Roorkee to the 110th Mile, rendered it advisable to extend the Waterway of the Falls which were built within these limits, so as to admit of the run of water over them being as little obstructed as possible, for the same reason ~~to the depths of~~ Foundations and floorings of a much more massive Description and greater depths than those originally

originally estimated for, were con=
=sidered to be indispensable; the
water way of Bridges was slightly
increased, their foundations strength=
=ened, and the usual means were
adopted, for overcoming the dan=
=gers and difficulties attendant
upon laying foundations in a
Sandy Soil.

The Number of Bridges
which had in former Estimates
been fixed on a Scale allowing
One bridge to every three Miles,
was more determinately arranged
on the actual wants of the Country;
the width of Roadway of Bridges
was increased to meet the High
Military, District, and Grand
Trunk Roads, and means of
access to the Canal water were
provided at all points where the
convenience of the Community
rendered such a course necessary.

At the points of departure
of the various Branches works
were provided for, by which the
supply might be regulated according to
the demand for Irrigation, or by
which a Branch itself, or the
Main Canal South of that Branch
might be laid dry, when ~~circum=~~
~~=stances relating to~~ repairs, or
other contingencies
~~Accounts~~, might render such
an arangement necessary.

~~Heads for Irrigation were~~
In the upper portion and in the
Sandy tracts of the Canal, con=
=fined to the higher levels of the
different Falls or descents of
Masonry; and in the lower dis=
=tricts the heads were attached
to the different Bridges ~~of which~~
~~they~~ forming a component part

of.

of the design

~~The line of Canal~~ It will be understood from the above detail that the line of the Canals had been entirely remodelled, not only in depth of Section to meet the 1st and 2nd Articles of the Rules that had been laid down for my guidance, but to meet the change in the distri-bution of the water which the alterations in the direction of the Branches in the Southern Divisions had rendered necessary

In ~~Conclusion~~ this report I observed, that the expenditure which was included in the Estimate embraced not only that of the works themselves but of all repairs and Establishments appertaining to the Ganges Canal from 1842 to the 30th June 1853 at which period, unless unforeseen accidents ~~would to prevent it~~ interpered, it was sup-posed that the works contained in this Estimate would be com-pleted; I pointed out that in the Southerly Divisions, the Masonry works had been placed on One general scale the perfect working out of which would depend very much upon localities; that in many cases the Estimated Cost would be in excess of the actual expend-iture; that I had endeavored to include in this Estimate the irregular works attached to the Tolents in the Ganges Khadir, as well as at Hurdwar and in the bed of the Ganges ~~River~~, and that it had been my object to exhibit in One Connected sheet the whole of the liabilities.—

Without laying any particu-lar

-lar stress on circumstances which the times rendered quite unavoid-able, I alluded to the many in-terruptions that had taken place to the progress of the works, since ground was first broken on the 16th April 1842, and to the Order of Government issued in 1846, giving to the Establishment and Laborers, both Hindoo and Mussulman, the Sunday in addition to the numerous holidays of their own particular faith.

The Total Amount of the Estimate of 1850, was as follows:

Total of Estimate for Works on the Main Line and its Branches	14160311	7	5
Total Expended on and Estimated for Establishments to 30th June 1833	1155936	14	11
Do for Ordinary Repairs Do	269733	3	0½
Do for Sundry Expenses	19824	14	2
Grand Total Cos Rupees	15605806	7	8½

At the period that this Estimate was submitted or up to the 30th June 1850, the following Expenditure had been incurred.

1st Division including Materials	2977731	10	5
2nd Do	1597234	15	11½
3rd Do	439434	2	4
4th Do	156587	13	6
5th Do	10382	15	8
6th Do	69989	7	11
Directors Office	122750	13	11
Grand Total Expended to the 30th June 1850	5374111	14	9½

It would be hopeless, and some-what unprofitable task to ~~introduce~~ advert to the various interruptions to progress that had taken place since the 11th of January 1848, the date on which I re-assumed charge of the works, and the date figured in the above Estimate

Estimate.. The second Sikh war deprived us for many months of the services of some of our most valuable Officers; sickness and other causes had led to the departure of others; but the Government steadily persevered in providing funds for every demand that we could make upon the public Treasuries; nor for a moment did the expenses of the Sikh war, nor the great demand for money, that such a concentration of forces must have called for, interfere with the expenditure on this great work of public utility.—

The above Estimate was framed under the idea that the works included in it, would be completed in three years. There were however, contingencies beyond those of the mere interruption from change of Executive Officers from sickness, or from the many other causes which influence the progress of works in general; the completion of the works in the Estimate, was in fact the completion of the works in the Northern Division, and the completion of these works depended entirely upon our success in Brick making; I have in the early part of this narrative pointed out the demand that is made upon the Engineers' time and patience by the absence of the wealthy and respectable Contractors who in Europe go hand in hand with the Engineer; this absence throws the whole of the ~~detail of~~ material manufacturing and collecting into the hands of the builder who in addition to his

his other numerous and respon-
-sible duties, has to manage the
detail and keep the accounts of
Every Brick and Lime kiln that
supplies his work. ~~with material~~;
The Executive Engineer in the
Northern Division was relieved from
this detail by the appointment
of an Officer whose duty was
confined to the collection of Material:
in the Southern Divisions, no ar-
-rangement of this sort had been
entered into, and the Executives
had to supply themselves to the
best of their ability.-

Mr Finn, the Executive Of-
-ficer in charge of the Material
Department of the Northern Division
had by the greatest perseverance,
and an energy not to be inter-
-rupted by disappointments,
succeeded in establishing Brick manufactories on a
large scale at four different
points in the Northern Division
~~Brick manufactories~~; in which
the kilns ~~The designs of~~ made according to a plan which had
been brought from Scinde by
Captain Weller of the Bengal
Engineers, ~~had with certain al-~~
~~-terations adapted to the particular~~
~~circumstances under which they~~
~~were used, and to the particular~~
~~wood fuel~~ which the forests in
the neighborhood produced, suc
-ceeded to an extent that had
hardly been anticipated. In-
-terruptions ~~which had arisen~~ arising
from strikes amongst the Brick
moulders, upon whom Mr Finn
had been for a long time depen-
-dant, had been completely put
a stop to by the introduction
of Brick making machinery

but altered to meet the particular circumstances under which they were used and the varieties of wood fuel

the

the model of which had been im=
=ported from England; the diffi=
=culties in fact which had marked
the early part of our experiments
in Brick making had entirely
ceased; and a Cold weather fa=
=vorable to progress, or one moder=
=ately free from rain was all that
was required to secure the manu=
=facture of bricks in sufficient
quantities to enable us to com=
=plete the works in the Khadir
within the period calculated
upon in my Estimate.

The working Season of 1850/
51, or that from the commence=
=ment of October 1850, began un=
=der very unfavorable auspices.
Lieutenant Fraser, the Executive
Engineer of the 2nd, and (as regards
the difficulty of the works) the
next in consequence to the North=
=ern Division, was unexpectedly
attacked by illness which render=
=ed his departure for Europe on
medical certificate a matter of
urgent necessity; the removal
of one of the Assistants of this
Division also ~~at this time~~ at the same time threw
the whole of the responsibilities
on the Shoulders of ~~the~~ remaining
Assistant, Mr Read, who totally
unaided had to carry on works
which were in active progress
on a line of upwards of 80
Miles ~~in~~ length.

The Cold weather rains
of 1850/51 were ~~of a nature~~ un=
=usually severe, and from their
continuing ~~through a long~~
~~successive period~~ uninterruptedly
for a long period
=ly, were more injurious to the
Brick manufactories than had
they

they been more violents, and fal-
=len at detached ~~places~~ times - the
effects of these rains were serious
=ly felt throughout the whole
line of the works, the quantity
of bricks and brick kilns that
~~were~~ was destroyed in the Southern
Divisions was very great, but the
evil was felt more severely in the
Northern Divisim where in ale
probability from its proximity
to the mountains and Forests
the~~m~~ rains were more severe than
Elsewhere .. For three weeks, or for
21 successive days during the
most active period of the season
and unfortunately at the early
part of the Cold weather, all at-
=tempts at burning or even ma-
=king bricks failed: the Brick
fields were totally cleared out,
the large parties of masons
which had been collected in
the hopes of an unfailing supply
of material had to be broken up
and a great number of men
had to be discharged.-

The discharging of men of
this class was a matter of very
serious importance; the detached
situation of Roorkee, and its
position with regard to neigh
=boring Towns, placed us in
dependence on Oude, Rajpootana
and the Country north of the
Sutlej; to break up the parties
of Masons, therefore, was tanta
=mount to delaying the com-
=pletion of the works; the nature
of our position, however, rendered
such a step necessary, and
although I have no doubt that
had fine weather succeeded, the
effects

19th June/53

Effects of these rains would have been in some degree neutralized by Mr. Firm's activity, the season continued to be a most unfavorable one; and I have no hesitation in placing the delay that has occurred in the completion of the Aqueduck and the works in general, to this most unpropitious Cold weather of 1850-1851.—

The destruction of Bricks which were in fact ~~the~~ first necessity for progress; the quantity of work yet remaining to be done in the 2nd Division (in the Executive duties of which Mr Read had succeeded Lieut Fraser) the impossibility of maintaining staff adequate to the efficient furtherance of progress determined me at this period to confine all my endeavours to completing the main line, and the two Branches into which it separates below Alleguh.—

There were many reasons, laying aside the causes above described, why this step was a very desirable one: The nature of the works in the Northern Di-vision, especially those connected with the great Aqueduck over the valley of the Solani River, appeared to point out the ad-visability of admitting in the first instance a moderate supply of water into the Canal, and to increase this supply gradually in a ratio proportion-ate to its effects upon the Chan-nel and Slopes. Whatever may be the knowledge at present pos-sessed by our Canal Engineers, this knowledge is confined to dealing with comparatively

small

Small bodies of water, (the maximum being 2250 cubic feet pr second) and with Channels of moderate dimensions; it would therefore be unwise to commence on the Ganges Canal with supplies so larger than we have been accustomed to ~~using~~; and whatever may have been the sanguine views either expressed or written on the subject of "at once throwing over the surface of the Doab "the means of Irrigation"; a deliberate reflection on the nature of the works, on the knowledge we at present possess, and on the dangers that we should incur by any precipitate measures with regard to supply; satisfies me that to do justice to this great undertaking we ought in the first year that water is admitted to confine the supply to a minimum - i.e. to that which now runs in the Eastern Jumna Canal, that by the admission of so small a body of water, we ~~shall~~ should be able to observe its effects upon the Aqueduct and the Sandy tracts that lie in the Muzzuffurnugger District, and be able by observation to suggest and to apply remedies for counteracting any of the evils that may practically exhibit themselves. The above supply would annually be increased under the advantages of a most useful experience, and by the time that the supply had arrived at an amount equal to 4500 Cubic feet pr second (or to double the amount in the Canals west of the Jumna) which ~~is that which corresponds~~ corresponds to the ~~to the water~~ quantity required for the Main Line

Line of canal and its two tail Branches; and by the time that the consolidation of the Earthwork both at the Aqueduct and elsewhere had been perfected, and the stability of the Channel insured; the opening out of the Branches towards Futtegurh and the Bolundshuhur and Koel Districts, the works of which would have been steadily going on during the above period, which we may call the probationary Service of the Main line, would be effected with the greatest security, and with the most satisfactory results.

I believe that the above is the soundest view that can be entertained of the Question, and that the objects desired by the Government will by following it, be the most certainly gained: but at any rate there ~~were~~ we're at the period when the question of discontinuing the branches was settled, practical reasons of a sufficiently obvious character, why the works could not be done. There was a clear necessity for limiting the progress ~~of the works to~~ by the ~~means that we had in the way of~~ Establishment we had at command which was ~~these Means were~~ barely sufficient to enable us to complete the works of the main line, a consummation ~~which was~~ indispensable to the admission of water; and it would have been impossible, without defeating this main object, to have extended our views in other directions or to have ~~in~~ ~~in~~ ~~in~~ ~~a~~ ~~—~~ ~~a~~ ~~—~~ ~~a~~ ~~—~~ divided our Establishments by undertaking additional works detached altogether from the main

line

line of operations

The country over which the Futtiguh Branch, which leaves the Main Canal at the 50½ Mile, passes, had been accurately examined by Mr Dodsworth the Surveyor, its surface had been covered by a reticulation of levels, which left the determination of the line a matter of no difficulty: this line had been tested by a series of levels, and proved by Mr Read: Bench marks had been established at every mile, and Brick making and Brick collect=ing had been steadily in pro=gress in those Districts over which he was able to exert his control

The County ~~over~~ which the Kool and Bolundshuhur branches extend~~s~~, lies in the 3rd Division: the estimated length of each of these lines is only ~~70~~ Miles: their direction and uses will be close=ly connected with the lining out and extent of the Rajbuhas or Main lines of water courses which will extend over that part of the Kool and Bolundshuhur Districts, toward the East of Hatpass and their direction will depend very much upon that of the Rajbuhas with respect to the tail discharges, and the connecting links which are in my idea of the Rajbuha system, one of the most indis=pensable elements —

The projects for these differ=ent lines as far as capacity of Channel and Bridge waterways are concerned having been ac==curately determined: the exca=vation and Masonry works can be carried on as soon as a

Supervising

Supervising Establishment is availa-
-ble for the purpose. I have in fact
shewn that some progress has al-
-ready been made on the Futtiguh
Branch, not only in laying down
the line, but in collecting Materials
On the Bolundshuhur Branch Six
Miles of the Channel have been com-
-pleted and some small progress
also has been made in Material
collecting

The disappointment arising
from interuptions to progress
which ~~for the Credit of my Estimate~~
~~of 1830~~ so unfortunately took place
during the Cold Season of 1830/31,
was in some degree alleviated,
by the results of the succeeding
years; the Seasons of 1831/32 and
1832/33 were marked by an un-
-interupted and steady advance
~~to progress~~ in the Northern Division,
on a Scale that could not have
been exceeded, and although very
considerable additions had been
made to the ~~Loans~~ designs, by which the
Amount of work to be executed
was increased, the improved or-
-ganization of our Establishments
and the increased means at
our disposal in the shape of
"Plant" placed us in a position
which at the close of the Season
of 1832/33, enabled us to arrive
at satisfactory conclusions as
to the period when the works
would be sufficiently advanced,
to allow of the admission of
water.—

In my Estimate of 1830
the above period had been fixed
at a date early in 1833/34, or by
the termination of the Month of
June

June 1853; the causes why this had not taken place have been sufficiently described, but it is satisfactory that under the necessity of making these explanations, and under the interruptions which led to such necessity, we find that the work of one season only in addition to those formerly contemplated has enabled us to bring these gigantic works to a conclusion at the end of the year, I use the term conclusion, as although a good deal stile remains in finishing off the Masonry and Earthworks, and to the fixings of the Dams; the line of Channel throughout the Northern Division has been brought to that state in which the Supply of water can be passed to the Southern Districts, and from whence may be dated a new era in the history of the Ganges Canal.

The works, however, on the Etawah Branch which were commenced at a later period than those elsewhere and which have been much retarded by want of European Establishment will at the period above mentioned be incomplete; they will be ready to receive water on the first Sixty Miles, and the Gihor Escape which is situated at the extremity of that distance will admit of a Stream being passed down the Channel. On the Cawnpoor Branch with the exception of the Locks into the Ganges, and the Terminal works in and near the Town of Cawnpoor, the whole line will be ready

to

to receive water, which may be
passed off in the meantime at
the different Escapes which are
situated at ~~distances~~ intervals down its
course; The works here have been
retarded by the departure ~~on~~
~~sick certificate~~ of the whole of
the Staff of the 6th Division in
which the Cawnpoor works were
situated, the consequent breaking
up of the Division, and the often
told tale of "want of Materials"

Amongst all the disappoint
=ments, that have arisen either
from the removal of Officers to
higher appointments, or to the
departure of others on medical
Certificate, by which the advance
=ment of work has been more or
less impeded; the Staff of the
Northern Division has remained
intact, without changes ex=
=cepting by additional members,
and with as little interruption
from sickness as could reasonably
have been expected; it would be
useless to expatiate on the ad=
=vantages that the works have
derived from an occurrence &
which considering that the time
alluded to extends through six
years is a very unusual one; it
has however given to each work
the inestimable benefit of &
having been carried on through
all its progress by the same in=
=dividuals, and it has given
me the benefit of an uninter=
=rupted connection with a
Staff of Officers who from the
highest to the lowest have
devoted their undivided atten=
=tion to the interests of the great
works upon which they have

been

been engaged - The names of the Officers who composed the Ganges Canal Staff on my joining the works in 18[illegible]8, were given in a former paragraph; I will close this Chapter by giving the names of those who were present at the works when the Canal was opened

1st Division Captain A Goodwyn, Engr
Lieutenant G: Price
Mr J: Parker
" J: Login
" W: Kay
" C: Anderson
" W.D. Rogan
" H.C: Kay
" J: Finn

2nd Division Mr J Read
Mainwaring

3rd Divisin Mr P Volk
Lieut Merrick

4th Divisin Lieut C.J. Hodgson Engr:
Cawnpoor Branch
" Lamb
" Willoughby Specifically for the Cawnpoor works

5th Division Lieut F. Whiting, Engr.
Etawah Branch
" Brownlow
" Angelo
" Span

The 6th Division which during the season of 1832 had been deprived of its Officers, (the Executive Engineer and One Assistant having gone away on Medical Certificate, and the remaining assistant having been removed to a higher appointment in the Road Department

=ment) had been incorporated with the 4th Division, the whole of the works of the Caunpoor branch having been placed under the management of Light Hodgson this same Officer

Mr Dodsworth who besides some very useful surveys in mapp=ing the details of the very in=tricate drainage of the Country through which the Caunpoor Branch took its course; had completed the whole of the Surveys and levels of the Country lying between the Ganges and the East Kalli Nudee, as well as that of the Rinde, the Sections of the Doab which were to be irrigated by the Futtiguhr and Elawah Branches; was at this period engaged on a series of levels for working out a Contour of the Ganges Khadir, or that portion of it which lies to the North & East of Roorkee, and between that place and the Sewalik mountains; an undertaking requiring ex=traordinary care patience and per=severance; and one of the high=est importance, as conveying by the most careful delineation of minute topographical de=tails, the fullest information on the drainage which crosses the canal works in the region under examination.

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PART, II

PART II

Topography of the Country and Description of the Works

CHAPTER. I

Prefatory Remarks

The canals for Irrigation which had hitherto been constructed in these Provinces, with exception to the water courses in the Deyra Doon and Rohilkund were ~~entirely~~ supplied exclusively from the River ~~Jumna~~ Jumna and consisted of two lines from whence they drew their supply. ~~There were Two Canals from this River~~, one on the right bank for the Irrigation of the Kurnal, Panipat, Delhi, and the Districts to the westward; the other on the left bank for the irrigation of the ~~numerous~~ Districts of Saharunpur, Muzaffarnuggur and Meerut lying on the right bank of the Hindun, ~~that extended~~ between from the Hills and Delhi.

The Country at the foot of the ~~near the Hills~~ Sewalik Range is ~~of these Canals runs~~ crossed by numerous mountain Torrents ~~to the Beds of~~ which the Jumna canals intersected, ~~Intersects~~, under circumstances of ~~Great~~ remarkable difficulty ~~nature, that~~. It will be interesting therefore to give a Sketch of the ~~i~~ peculiarities of surface and of the ~~general~~ Profile of the Country in the neighbourhood of ~~upon~~ which the Canals ~~Torrents themselves run, as~~ preparatory to entering upon a ~~the~~ description of the Ganges and its drainage, ~~as connected with~~ the Subject to which this Chapter is more especially directed.—

In tracing on ~~looking at~~ the Map the ~~East~~ direction of the Jumna from the point where it leaves the Hills to Delhi, and observing the position of the Eastern and Western Jumna Canals with their

~~Source~~

heads of supply
~~Sources~~ opposite to each other, their
~~beds running~~ alignements parallel and their
Escape or tail water joining the
parent stream at points also op-
-posite, an indifferent observer
would naturally conclude ~~consider~~ that
under ~~such~~ circumstances of strikingly coincident
~~circumstances~~
such as were due to contour
~~any~~ difficulties ~~of~~ surface would
be common to both, and that the
works required for the maintenance
of one Canal, would (caeteris paribus
~~supposing the capacities of both Canals to be the same~~)
be similar to those
of the other. —

In the Centrical and Southern
regions there is a considerable cor-
-respondence between the levels of
both Canals; the Step which occurs
into the Khadir near the village
of Surrowli on the Eastern Jumna
Canal, and which is passed by
a succession of Falls and Lockage
is on the Delhi Canal maintained
on the high level into the City by
which means an ample supply
of water is provided for the Inhabi-
-tants; the rapid descent into the
Jumna takes place almost im-
-mediately at the end, the greater
part of the Tail water passing
through and turning flour Mills,
and the whole escaping over paved
and well protected Channels into
the River.

It is in the Northern region
in ~~which~~ that we observe the greatest
difference. On the west of the
Jumna, the Canal on its leaving
the Parent Stream, passes over wide
and open beds of shingle, upon
which the force of the current ~~stream~~ is able to ex-
-haust itself; these ~~shingle~~ beds
extend ~~to a distance of 36 miles~~

as

In the centrical & Southern regions
the Levels of both Canals correspond
generally with each other. On the E
bank however the limit of the river val
or Khadir is thrown back as far as the
of Surrowli on the Eastern Jumna Ca
a distance of about 12 miles from the
bed of the stream, & the step thereby caus
passed by a succession of Falls & Lock
On the western bank the high land bou
the Khadir is maintained up to the imm
vicinity of the city of Delhi to which
Western Jumna Canal is enabled to pro
an abundant supply of water for domestic
The rapid descent into the River val
itself takes place virtually at the
of the Canal, & the fall thus obtained is
nomised for flour mills worked by the
Plus water for which an Escape into th
River is provided, through paved a
well protected channels.

as far South as the Dadoo poor Dam, to a distance of 16 miles and during the whole of their course are the receptacles of the Country drainage, which passes off during floods either over the Country or through breaches which are repaired annually after the rainy months. The Dadoopoor Dam which regulates the supply into the Canal Channel, is also the escape for the flood water of the Putralla and Tombe, the latter being a Torrent of very large dimensions From the ~~Dadoopoor~~ Dam the Canal proceeds along the low Land, ~~and continues on these levels~~ until it reaches a point 60 Miles from Dadoopoor, at which it has gained the levels of the high Country ~~on which it con-~~ tinues to follow the range to Delhi on its left, and to Hansi on its right branch.

Although therefore Masonry works are provided on this Canal for the passage of the Putralla and Tombe Torrents, the two following facts viz: First that ~~of~~ 60 Miles of its course are ~~being~~ ~~upon~~ ~~ridges~~ in the Khadir or low lands of the Jumna ~~River~~ through which the channel ~~it is allowed to~~ wanders with all the tortuosities of a natural River, and Secondly that ~~the fact~~ ~~of~~ the whole line after its escape from the Shingle beds, ~~being~~ in out of the influence of the rapid slopes which are natural to the proximity of the Mountains, render the ~~passing off~~ occurrence of floods even of an extraordinary ~~nature~~ volume, a matter of comparatively little moment. Leaving out of the Question the Puttralla and Tombe, floods do in fact pass directly over the course

of this canal ~~both~~ on the tracts both above ~~and those~~ and below Dadoopoor, without doing any material injury either to the ~~Canal~~ works, or to the Country.-

The Eastern Jumna Canal ~~the Head of which is opposite to that on the west~~, after passing down the Shingly bed of the Boodhee Jumna for the short distance of 4 Miles, enters on deep cutting and takes a South Easterly direction, ~~by deep Cutting, which~~ commences at the village of Nyashuhur; from this point it plunges at once into all the difficulties peculiar to ~~that attend upon~~ a line crossing mountain drain=age at right angles to its course. The Raipoor, Satoowala, Nogong and Muskuna; four mountain Torents of greater or less dimen=sions are passed within a distance of 10 Miles from the Nyashuhur deep Cutting. The Muskuna and the Nogong are Torents of considerable magnitude, and are provided with Masonry Dams for the passage of Floods during rains. After passing the Muskuna, the Eastern Jumna Canal Channel continues on the high land of the Country

With a similar declivity there=fore, on both the Eastern and Western Jumna Canals between their terminal points, its distribution in detail ~~of this declivity~~ leads to most remarkable differences in the requirements for works. The great Northern Step which on the West=ern Canal is passed by a suc=cession of wide beds of Shingle,

with

with considerable tortuosity of Channel through low or Khadir country, is on the Eastern line maintained for many miles on the high land in the face of numerous Mountain Torrents, and finally overcome by a Succession of Masonry falls. The extent of the Shingle beds on the west of the Jumna therefore, points out the comparatively easy way in which this step of country is passed on the Canal on that side of the Jumna, and explains at once the absence of any necessity for artificial descents or expensive works for overcoming the excess of slope of the country: in opposition to the necessity for such works on the Eastern Canal, where the object common to both, had to be accomplished under such different circumstances

The works on the Delhi or Western Jumna Canal were ~~partly~~ partly designed by Capt^n Blane of the Bengal Engineers, and partly by Colonel Colvin C.B. of the same Corps. Those of the Eastern Jumna Canal were designed by Colonel Robert Smith C.B. of the Bengal Engineers; on these latter works my early career as an Officer of the Canal Department was passed, I joined Lt. Smith's in 1825 shortly after the works were commenced ~~in 1825~~, and superintended the opening of the Canal in 1830.

The Mountain Torrents ~~which~~ connected with the Eastern Jumna Canal have naturally been the impediments to regularity of supply, as well as to the repose of the Superintendent, but time and

There characteristic differences accordingly determine the nature of the means to be employed in passing this step of country. On the West the broad & winding beds of shingle absorb the fall naturally & easily, & thus obviate the necessity for artificial descents. On the East where no such wide shingly tracts are to be met with but where the Canal enters at once on the high land of the Country the common object must be attained by purely artificial & expensive falls.

and experience have ~~rendered~~ given the Establishment ~~secure as to their~~ a perfect command over them, ~~and~~ while the constant attention that has been given to their vagaries, and the application of Remedies when such were required, have reduced to a matter of simplicity ~~that~~ what ~~which~~ in the early days ~~of the History~~ of the Canal was con-=sidered by no means of a simple nature. —

~~These was~~ One very remark-=able feature in the Topography of the Country over which the Eastern Yumna Canal passed, ~~which~~ will give at once a Key to the general remedies that were at hand for ~~Rendering the Canal of some of its Inherent~~ enabling us to contend against the difficulties due to the Torrents and as these were remedies which were not always to be found when Projecting Canal alignments, I must allude to them here, in anticipation of what has to come hereafter. —

From the description before given, of the direction taken by the Eastern Yumna Canal on its leaving the Parent Stream, and entering upon the high land at Nyashuhur, it will be observed that the very circumstance of the line of Canal running at right angles to the drainage of the Mountains and conse-=quently in a direction paral-=lel to those Mountains, shewed that the Country sloped from West to East, and therefore that although the Mountain drainage in its natural State crossed the Canal line, we held

the

the power in our hands of changing the course of this drainage at points lying above the canal channel, and by passing the water off to the Eastward, to relieve the works from a great deal of the inconvenience to which they were naturally subjected.—

A leading feature in the original project ~~for the execution of these works~~, was the neutralization of the effects of the Muskurra upon the works at Kulsea, by taking advantage of this natural arangement of slopes and by turning its waters to the Eastward, ~~to~~ connecting them at three different points with Rivers which were tributary to the Bindun; the effects of these arrangements has been to reduce ~~the stream of~~ the Muskurra at its point of contact with the Masonry Dam at Kulsea, to a comparatively inconsiderable volume. The Datonwalla drainage has on the same principle been turned into the Nogong River; at times the violence of a Nogong flood has been relieved by allowing a portion of its volume to pass off down the Canal Channel towards the Muskurra; ~~and~~ The influence of the arrangement of surface slopes, ~~but in the case of the Torents connected with the works of the Eastern Jumna Canal~~ above described has therefore been undoubtedly of the highest importance and value to the works on the Eastern Jumna Canal.—

It is with these peculiarities of

of drainage ~~which I have above described~~, as affecting the works in the Northern District of the Eastern Jumna Canal, ~~and~~ which in itself ~~is~~ in fact ~~constitutes~~ the western watershed ~~drainage~~ line of the North=Ern Doab and with the details of this ~~line~~ tract of country fresh in recollection, that I would turn the readers attention to the Eastern watershed, or the drainage which flows towards the Ganges River. The line of separation is well defined; the western drainage including the west Kalli Nudi and its trib.=utaries flows into the Jumna; the Eastern including the East Kalli Nudi and its tributaries flows into the Ganges: the point of separation in the Sewaliks being the Shahjuhanpoor and Koonjnawur passes, to reach which from the plains ~~there is~~ a section of country free from cross drainage is traversed: this section being in fact, the back bone of the Northern Doab.—

It will be observed by refer=ring to the Map that from the point of watershed or from that ravine in the Hills which supplies the most westerly tributary of the Solani River, there is a bank which extends in a South Easterly direction, increasing in departure from the Hills, as it proceeds on=wards; upon the edge of this bank are situated the Towns of Bhugwanpoor, Roorkee, Jourassi, Landoura, Noornugger, and on and near its approach to the main stream of the River Ganges

the

the Towns of Bhookurheri and Sookurtal.. These Towns overlook as it were an extensive valley, the maximum depression of which must be very considerable, ~~but~~ Opposite the Town of Noor-nuggur and at the village of Badshahpoor, from which my line of levels of 1836, commenced ~~was taken~~, this depression was found to be 8hs feet - Thl~~s~~ tract of Country reported to ~~which~~ ~~it~~ bounded by the Sewaliks and the high bank above described receives the whole of the hill drain-age from the western extremity of the watershed; this drainage is in fact restricted to the above limits by a well defined barrier. To the west of the high bank ~~and to the line of Towns situated thereupon,~~ the drainage of the Country passes off by ~~ill defined~~ shallow tributaries to the west Kalli Nudii, and ultimately to the Jumna River; a series of Sand Hills (provinci-ally termed Bhoor) is here a remarkable feature; these ~~Sand hills which~~ shew themselves in undulating elevations and depressions running parallel to the drainage of the west Kalli Nudii ~~sometimes however they appear either to be lines parallel to the drainage, or~~ are found in ram-ifications thrown off from the main line, pierced at points to admit of the passage of the side drainage, ~~and~~ occasionally ~~shewing themselves~~ in extended and ~~in~~ unbroken ridges. The slope of the Country is from the ~~Lip~~ edge of the high bank towards the westward, and strange as it

may

may appear the water shed line of the Jumna and Ganges passes directly along the top of the ridge on which the towns are situated. —

The low tract of country ~ which I have ~~above~~ before described, ~~and which~~ is that portion of the Ganges Khadir, with which the works on the Canal are con=nected. ~~It will be understood to be~~ It is of a triangular form, bounded on the North East by the ~~Chain of Hills called the~~ Sewalik Hills on the South west and South by a Steppe or bank, and on the South and East by the Ganges River. — The Sewaliks on the North East, and the bank which lies on the South west and South ~~terminate in~~ meet at an acute angle ~~at a~~ near the ~ Thanjuhanpoor and Koojnawn passes ~~in the former range of Hills~~: the bank as I have before described, decreasing in abrupt=ness up to this ~~acute angle, near~~ point or junction, in the vicinity of which it is lost entirely. The Khadir receives the whole of the drainage up to this angle, which is the ~~true~~ point of departure of the watershed separating the drainage of the Jumna and Ganges Rivers. The depression of the ~~triangular tract of country~~ so thus defined is by no means uniform, as to the westward there is an isolated portion of it ~~tract~~ considerably elevated, on which are situated the Towns of Kheri Imli, and numerous villages: the ~~tract in question~~ part of this elevated portion is much intersected and cut up by Channels

Channels, and it is separated, or nearly so, in its centre, by a large ravine receiving a portion of the drainage collected in the Forests. In addition to this main insular tract of high land, there are other smaller mounds in detached or outlying positions, upon which villages have been built. The Town or Village of Dowlutpoor is thus situated, and to the North of Dowlutpoor these mounds or knolls appear to be ramifications from the higher levels (lying at the foot of the Hills) above which ~~point the surface of the Country~~ they are much elevated. The drainage is well marked, and may be divided into three distinct Basins, the most westerly one embracing ~~that of~~ all the Hills and Country lying to the North of Kheir and Shah Munsoor, including the drainage from mountain Torrents ~~extending on~~ over a distance of 8 Miles from the Western angle; this which is by far the most extensive, has its waters collected into the Solapi River, ~~flows along the foot of the~~ which flows at the base of ~~high bank, and under the~~ the high bank, and ~~of the Solani River~~ reaches the Ganges in the neighborhood of Bhookurkeri.

The Second or Centrical Basin is ~~that of~~ draining by the Rutmoo River, the heads of which are in the neighborhood of Shah Munsoor, this River receives the waters falling ~~Drainage on of~~ 11 Miles of mountain, and is a tributary of the Solani, which it joins under the Town of Doundassi.

The

The third is the Puttri Basin ~~River~~ which receives all the water from the Country between the Towns of Gurh and Dowallapoor with a hill drainage of Six miles.- The drainage of the Puttri Basin ~~River~~ however, is in the earlier parts of its course divided into two distinct Mountain Torrents, the one to the westward being 'par 'excellence' the Puttri, ~~River~~ that to the Eastward and in the neigh- =boorhood of Dowallapoor being called the Ranipoor River, ~~at this part of their course.~~ These two branches, as they may be designated, run in separate, although ~~in~~ ill defined basins, ~~they are~~ being to all intents and pur- =poses distinct Torrents, and as such have been separately treated

To the Eastward of the Puttri drainage, or rather to the Eastward of that drainage connected with the Ranipoor River, and the Town of Hurdwar, ~~at which latter point~~ where the Sewalik Hills impinge upon the Ganges River, there is a good deal of Scattered drainage, which during heavy rains comes down with con- =siderable rapidity from the low Spurs and Ridges which lie at the foot of the Sewaliks. the water derived from this source passes directly into the Ganges through numerous small Channels which lie to the South of Hurdwar and Kunkhal.

The Solani and Rutmoo Rivers, ~~which are supplied by the drainage of the Country to~~ the

~~the~~

Exhibit

~~the Westward~~, exhibit in their course under the bank at Bhugwanpoor and Roorkee, unmistakeable marks of their mountain origin; they are 'Raos'* in the most extended sense, with wide sandy beds, and although during exceedingly dry seasons, shewing no external stream, bearing under a dry sandy surface, perennial spring water.

The Puttri and Ramipoor Rivers, ~~as those which are connected with the Puttri drainage~~ differ very materially from those above described. The Map which shews in detail the courses of all the Khadir drainage will give a better idea of the nature of this drainage in the direction of its different Channels than I can give in description. In the proximity of the Hills, ~~however~~, they exhibit the character of well defined mountain Torrents, with Shingly and Sandy beds; ~~a character that, ceases and be-~~ which they lose however at lower levels ~~Cones~~ where well marked sections of beds present

---

* Rao (Sorrino, Torrent) a provincial name given to the Shallow sandy or Shingle beds directly connected with the Hills, the drainage of which is carried off by these Channels. During the greater portion of the year they are either perfectly dry, or with a small stream running in them. After heavy rain they are liable to severe freshes and floods, and at this time are impassible for man or beast. The great declivity upon which they run enables them to pour out a volume of water with immense and dangerous velocity. These floods, however, do not last above a few hours, and subside as rapidly as they commenced.—

themselves only at detached points
~~comes entirely lost by the absence~~
~~of all marks of watercourse &~~
scattered here & there over the surface
~~existing in detached bits dest~~
~~tered here and there over the sur~~
~~face of the country~~. In a more
of the country
Southerly direction these detached
bits of drainage become united
into One perfect channel, which
skirting the Puttri Forest, wanders
ultimately over the low lands,
and joins the labyrinth of Rivers
which intersect the Khadir at
its South Eastern extremity.—
In further illustration of the
~~Characters~~ Features of the country of which
so much necessarily must be
said in explanation of our
proceedings, I may observe
that although Spring water may
be and is even at the hottest
periods of the year, found near
the surface ~~in~~ at the immediate
~~foot~~ Skirting of the Hills, it is one of the
characteristic phenomena of
the line of country ~~which lies~~ adjacent to
~~at the foot of the Sewaliks~~ &
that on a belt extending to an
irregular width ~~which lies~~ South
of and parallel to the Hills, &
water is only found at consider-
able depths, whereas at points
lying beyond this belt, Spring
water either appears at the Sur-
face, or can be obtained by very moderate ex-
cavations.— In exemplifica-
tion of the above, although
somewhat anticipating the
events which I am about to
describe, it was found that in
all our excavations lying &
within a moderate distance
from the foot of the Hills, neither

Spring

Spring water nor any appearance of Spring water exhibited itself; as we got further from the Hills and arrived at the Pakeri ~~and~~ on approach to the Rutmoo Valley, also Spring water became an evil of very serious importance. the Baushahpoor Nulla, with which ~~is a tributary of the Rutmoo,~~ we came in contact between the Pakri and ~~and which rises in the Forests~~ Rutmoo valleys ~~to the North~~, was in fact a perennial Stream. ~~[illegible]~~ the ridge between the Rutmoo and the Solani River was by no means free from an inconvenience, which we did not get rid of until we reached the Excavations on the high land at Roorkee. The evils which arose from the interference of Springs were really ~~in accordance with those which~~ such as we had anticipated; and although these evils became very much enhanced by the necessity ~~of~~ for altering my original design which had comparatively speaking avoided the inconveniences of deep digging in the tract connected with Springs; the difficulties that we met with did not after all exceed our expectations. —

With the exception of that immediately in the neighbourhood of Kunkul and Burdwan, the whole of the Country lying at the foot of the Sewaliks, and at the heads of the Rivers above described was at the period of my original Surveys under

Forest

forest and uncultivated, and although the triangular tract which I have described under the name of the Khadir was neither wanting in villages nor population, the greater portion of it was jungle and marsh; of the latter there were some very extensive tracts connected with the Puttri and situated centrically and to the Eastward of Tartuk Shah; ~~as well as~~ and others with the Solani and Bhat rivers which under the name of the Jogiwalla Sheel, covered a ~~very extensive~~ large area of country near Bhookuheri, ~~and~~ at the time ~~that~~ which I talk of was supposed to be inaccessible, as it was certainly avoided by those who visited the Khadir on Tiger Shooting expeditions

If a tolerably accurate idea has been given by the above detail of the peculiar features and character of the Ganges Khadir and of the Mountain Torrents which flow through it, I shall be able I hope to render an account of my operations for laying down a line of Canal ~~through it~~ in a way sufficiently distinct to be (especially if the aid of a sketch is sought) ~~with the aid of a Map~~ perfectly intelligible. —

In commencing the Examination of the Khadir, ~~and having~~ in 1836 I took a Section on its Southern limit at Badshahpoor and Kumbhera ~~(Kumbhera~~ the latter being a fixed point or bench mark situated on the top of the high bank which

as

~~as~~ I have described ~~it~~ as being the South western boundary of the low land I determined on obtaining a similar section on an extreme Northern limit and for this purpose, ~~caused~~ a line of ~~levels~~ cuts from a point on the Ganges between Hurdwar and Kunkul, touching the Towns of Kheri and Nanka, continuing down the high land by Bhugwanpoor, Roorkee and Mungloor, until ~~it~~ arrived at the Kumbhera bench mark; this gave me an uninterrupted circle of 34 Miles; intermediate levels across that portion of the Khadir lying between Kheri and the villages Eastward of Roorkee, brought the whole profile and its capabilities for canal purposes distinctly under review; the result in fact shewed that there were two lines open for adoption, viz^t: One on an extreme Circle by which the bed of the Canal, would be maintained on a level corresponding with the surface of the Country; the other, on a more direct line which, ~~by~~ crossing the valley of the Solani River, by an Aqueduct, would deliver the water on the high land of the Doab immediately at the Town of Roorkee.-

For the circuitous line we had the example of the Jumna Canals before us, where the stream when crossing the beds of Mountain Torrents was retained by Dams with Sluices for regulating, and passing off floods; and we had in its favor the comparative security of keeping to the earth's surface, instead of carrying the Canal water at levels far elevated above it; in opposition to these advantages which are to a certain

degree

degree admitted, we had the evils of a more extended course, through a wild and broken Forest country, with drainage very much divided very much scattered, and with the certainty of that species of inundation which necessarily attends the Dam System, It was impossible to calculate on the extent of the inundation that would be incurred by this circuitous route, but it would occur on the upstream side of every Dam, and of these there could not be less than Six, the whole of which would be situated at points where the great declivity of bed of the different Mountain Torents over the course of which they would have to be built, would necessarily, it was supposed, lead to all the evils of retrogression of levels on their tails, of which we had had dangerous experience in the works on the Eastern Jumna Canal. The objectionable influence in a Sanatory point of view, that the introduction of so much inundation would exert upon the neighbouring country was by no means the least effective in leading me, and ultimately those who were called to give their Opinion on the subject, to reject this Circuitous Line. —

The direct route which was confined to the more civilized part of the Khadir passed the Rutmoo River immediately to the west of Peeran Kuleeur, and bearing ~~upon a~~ directly ~~thence~~ upon Roorkee, reached the Solani Valley at a point between the villages of Bajoohera and Mahewun: from this point to Roorkee which was

on

on the high land of the Doab the breadth of the valley was 23/4 Miles and its maximum de=pression below the estimated bed of the Canal was twenty four feet The objections to this course were first of all, the novelty and probable danger of a design which con=templated the transport of a large body of water at high levels above the surface of the Country; and secondly, the ex=pense, which would undoubtedly be great; ~~as a recompense to~~ To counterbalance these objections however, we had the advantages of ~~escaping from~~ avoiding inundation; of maintaining a line through a more healthy and accessible country; of keeping the Canal in its pas=sage over the Solani free from the Sand and Silt, which ~~is an~~ are inherent evils where a Canal comes in Contact with a mountain Tor=rent; and of being able to main=tain an ~~free and open~~ undimpeded line of com=munication across the Solani Valley in connection with the more Northerly works.—

Even in this direct route which appeared to be in every way so superior to the other, the Rutmoo River ~~to cross~~ had to be passed by the Dam system, as it obtains on the Jumna Canals. it was concluded however that there would be no difficulty in so designing the works as that the evil of inundation on the upstream side might be got rid of, by retaining the Canal water in its own Channel, and ~~by relie=ving~~ carrying the drainage which during the dry months comes down the River, or ~~that which arose from~~ is caused by leakage

leakage ~~and escape~~ from the Canal
Channel, ~~by constructing~~ through drains
under the Canal, so that the water
might pass ~~of~~ down the course
of the River - The profile of the
Country was favorable to the
adoption of the Aqueduct system
over the Rutmoo as well as over
the Solani, and the advantages
attending such a plan in carry
-ing the Canal water free from
the Silt and Rubbish of the Rutmoo
Torent were much in its favor,
but very extended lines of Earthen
Embankment are not only very
expensive in the first instance,
but require much subsequent
looking after, entailing upon
the Government a large Establish
-ment for their supervision; the
Masonry portion of the Aqueduct
which would necessarily be over
the Ras itself, would form the
difficulties of foundation be equal
in expense to that ~~of the building~~
over the Solani. and there was
no object in ~~retaining~~ upholding the levels
of the Canal bed, over the valley
of the Rutmoo, as the natural
Slope of the Country in advance
was sufficient for all the purposes
of the Project, and to have con-
-tinued the high levels ~~over the~~ thus
Rutmoo would have necessarily led
to the ~~necessity~~ construction of a series of Falls
on the Peeran Kulleem ridge in-
-termediate between the Two Aque-
-ducts - A Dam therefore on the
principle of those used for the
Tombe and Muskuna Rivers
on the Dumna Canals, was finally
~~determined on~~ adopted for the Rutmoo
~~River~~

The Project that I submitted
at this Period, was accompanied
by -

by a Report, in which when dis-
-cussing the merits and demerits
of the two courses ~~which were~~
open for selection, I gave my
reasons for preferring the line bearing
upon Roorkee and crossing the
Solani valley by an aqueduct.
As the project and Estimate which
were at that time submitted were
on a very small scale and were
drawn up simply with a view
of establishing the fact that a
remunerative work might be
constructed, there appears to be
no object in drawing any further
attention to them; they were how-
-ever, the basis upon which the
Committee which was ordered to
report on the project, ~~determined~~ examined
their plans, and the line ~~that I~~
~~had~~ adopted by me in the original pro-
-ject was in every respect the
same as that which the Com-
-mittee selected. To meet the
desires of Government, and in
accordance with the views ~~that~~
I had ~~put forward~~ expressed in the report
above alluded to, the Committee
in looking to the Irrigation of a
more extended tract of country,
deemed it advisable to increase
the head supply from 1000 ~~to an amount~~
~~equal~~ to 6750 cubic feet per second
~~and consequently~~ in consequence of which it became necessary by so doing
to increase the capacity of the
canal excavations, and to ex-
-tend the dimensions of the works
The result of this decision and
the approval of Government to
the recommendations of the
Committee, led to my Report
and Estimate of 1845, to which
especial allusions have been
made in a former Chapter.

Without

Without, therefore, entering into any description of the works of the former estimate, it will be sufficient, as the line of country ~~for~~ which they were projected was precisely the same, to review in detail the works that have actually been constructed, ~~to explain the causes of alterations to these works~~ in their original state, and in as succinct a manner as possible to make the reader acquainted with the peculiarities of the surface of the country upon which they have been executed. —

With this view I shall in preference to wearying the attention by tedious and unbroken descriptions of country and works extending throughout the whole length of the Canal, diversify the subject by separating the detail into three sections each of which contains in itself ~~themselves~~ peculiarities of a sufficiently marked order, to render such a division not only convenient, but ~~in some degree more~~ natural and conducive ~~appropriate~~ to distinct explanation

The three great divisions which naturally arise under the above view of the Question, are:

I The Ganges Khadir, extending from the Ganges River to the high land of the Doab at Roorkee; the length of Canal course being in this section 19 Miles —

II The Country from Roorkee to Nanoor marked by great declivity of fall in the surface and by its connection with the Bhoor or sand tracts:

the

The length of the canal on this Section being 161 miles —

iii. The Country from Nanoon to the Ganges and Jumna Rivers, marked by a deficiency of fall in the Surface of the Country, and by its connection with the Rinde, Seyngoor, Pandoo, and other Rivers which drain the flat lands of the Central Districts. The length of the canals on this Section being 345 miles

CHAPTER II

Detail of Alignement and Works

I.

i "The Ganges Khadir extending from "the Ganges River to the high "land of the Doab at Roorkee".

The main stream of the Ganges, the discharge of which is estimated in the driest months of the year at 8000 Cubic feet per second, after passing through the Valley of Deyra opens upon the plains of India by a well defined gorge, or as it may be termed a natural breach in the Sewalik mountains. Immediately on the Right, and close at the foot of these mountains are situated the Town and Temples of Hurdwar. On the left is the Chandni Pahar, a hill of a remarkably picturesque outline, on the top of which is a temple, and place of pilgrimage connected with Hurdwar itself. The River may be said to occupy the whole of this Gorge, the width of which at its narrowest point is about one Mile. Like all the great Rivers from Cyprus, however, ~~in those parts of their course~~ where they are in immediate Connection with the

Mountains

Mountains, where their beds ~~are~~ consist ~~marked by~~ shingle, and ~~when the~~ their declivity ~~of bed~~ is great, This wide expanse is intersected by numerous Channels, separated by well wooded Islands, many of which are placed beyond the reach of high flood water, and ~~many of them~~ are partially cleared by the labor of the husbandman. A branch which was formed by an Island or Islands of this sort, passed directly under the Town of Hurdwar and proceeding onwards in a tole=ably even and unbroken section, rejoined the Parent River at a point below Kunkhul, ~~another~~ and a large Town ~~which is~~ situated about 1½ miles below Hurdwar.—

The Main ~~stream of the~~ River which runs under precipitous banks ~~which it has~~ scarped by its own action ~~itself~~ on the left, throws out on its right and within a distance of 2½ Miles above Hurdwar a ~~branch~~ minor stream of considerable importance, which under all the fluctuations that ~~attend upon~~ character is a these constantly varying beds, appears to carry, and to have carried for years, a very uniform supply of about Onethird of the whole volume. From this branch the Inhabitants of Hurdwar and Kunkhul have been in the habit of bringing a water course for the purpose of supplying the Towns ~~with water~~, the Priests being interested in ~~obtaining a supply for~~ maintaining water for their Ghats or bathing places, the com=munity in general depending upon this supply for water both for drinking and for culinary pur=poses

=poses, for turning Corn Mills, and to a moderate extent for the Irriga=tion of their Gardens.—

The Head works of the Ganges Canal therefore were in limine, determined by the Priests and the people, so far as supply was concerned, it was only a matter of degree, The source from whence ~~they derived their supply~~ my ground was ample for the purposes of a Canal and the only questions ~~which were~~ left for my consideration, were those of Capabilities; which depend=ed entirely on the results of a very simple Series of longitudinal and cross sections, the former extending from the de=parture of the branch (to which I have before alluded, as the source of supply) from Burdwan to a point South of Kunkul, and the latter giving an accurate profile of the gorge through which the River flowed. The high water marks of floods, the effects that these floods had upon the islands, and the capacity of the different Channels, especially that one which passed under the Towns of Burdwan and Kunkul had also to be ascertained. A Series of levels on the above plan, in con=nection with a Survey shewing the full details of Channels and Islands, disentangled the whole question from any difficulties, and at the same time unmistakeably determined the point from whence the head of the Canal was to leave the branch—

There was a well trodden foot path down a Ravine leading to the waters edge in the branch running from Burdwan to Kunkul. At the head of this Ravine and overhanging the River was a large

(Ficus religiosa)
large Pepul Tree, and at its foot
a Linyam. The Spot itself went
by the name of the Gunes Ghat,
but there was neither building
nor temple, nor flight of steps,
to shew that the ~~Spot~~ Ghat in question
was remarkable for its sanctity.
The ~~Spot in question~~ Gunes Ghat was situated
on the down Stream side of two
mountain Torrents of no great
dimensions, but of sufficient
consideration to render their inlet
into the Canal Channel a matter
of inconvenience. The section of
the branch at the Spot in question
was well defined, the sides were
steep and the island on which
its left side rested, was one that
was raised above the ~~bunds~~ limits of
inundation, and consequently
well adapted to my purposes.
The Spot ~~in question~~ selected was situated
in the lands of the Myapoor Estate

The Gunes Ghat, therefore, was
determined upon as the point at
which the Head works should
be erected, and from whence the
Canal Excavation should com-
mence ~~its course~~.

For the details of the exam-
ination of the bed of the Ganges
and the branch which hall now
become a leading feature in the
Project, the Atlas which accom-
panies this volume must be
consulted. My levels, however,
were carried from a point North
of Kunkul to the junction of the
branch with the Main River
which as I have before noted
takes place at about 2¼ Miles
~~South of~~ about Hindwar. The total
declivity of Surface on this line
was 34'. 10·4" in a distance of 19864 feet
the branch itself was well adapted

to

to the purposes for which it was required, its average width was 300 feet and its Section at those points where it was free from breaches was deep and well de=fined. Immediately above Burdwan however, the branch is connected on its right with a good deal of drainage running from the hills and flats situated in the Deyra Valley, but inconvenient as this might be, it presented no obsta=cles to the passage of the Canal supply. At a point on the + South and immediately below the Toron, a second tributary which is designated the Lulta Rao enters the branch on the right; this Lulta Rao is a mountain Torent of no great magnitude but it runs on an extraordina=rily steep Slope, and comes into connection with the Branch at a point almost immediately after it has left the mountains. It will in all probability be the cause of annoyance in the + quantity of Silt with which its waters during floods are loaded; its position is, however, above the Masonry works at the Canal Head, and I anticipate that the evils which might arise from the Silt ~~which is~~ brought down by this Torent will be very much modified by the streams which will hereafter pass down the branch, and at all events that whatever the Amount of Silt may be, its occurrence at intervals and during the rainy months, will lead to little or no interuption to the bed of the Channel. I look upon the Silt that will be here deposited much

in

in the same light as I do that ~~on the Eastern Jumna Canal works~~ which, after each flood in the Muskuna, is deposited on the upstream side of the Regulator of the Eastern Jumna Canal at Kulsea and between that ^ point and the Dam; ~~the quantity~~ this deposit is so infinitesimally small as compared with the area of the Canal bed below the Regulator, that its admission ~~into the Canal~~ is a matter of no importance, and of no consideration whatever. At the time ~~that~~ when I visited the branch in 1839 at the point ~~where it leaves the parent stream~~ the volume of water passing down its course from the main Stream was equal to 2500 Cubic feet per ^ second; there were ~~with~~ strong rapids at its mouth, offering ^ in themselves ~~offering~~ facilities for the admission ^ of a further supply. Immediately North of Kurdwar a great portion of this water escapes through a wide extended Channel that passed off to the main stream, and opposite the Great Ghat at the Town itself, a further escape was effected by a similar Chan=nel. There was ^ this a smaller ~~escape~~ Channel situated further down the branch, which was only ef=fective as a line of escape during heavy floods: it was proposed to construct ~~applie~~ temporary bunds or embankments across the heads of these different ^ Escape Channels, and by advancing a Spur into the River at the head of the supply branch, to obtain from the main stream ^ whatever quantity ~~supplies~~ was necessary. These were my views in 1839-1840 when designing the original works, and they have been carried out very

closely

closely, or as closely as the changes that have taken place in the bed of the River would admit of; these changes in fact are exceedingly small, and in the year 1833, they are confined to a diminution of water in the branch and an enlargement of the escape Channel opposite the main Ghat at Kurdwar: in other respects the State of the River and its numerous Channels and Islands is much the same as when I first visited ~~them~~ them in 1839.

During the year 1832 certain ~~preliminary~~ preparatory measures were adopted ~~in preparation~~ for excavating the Canal Channel down the Branch. These measures consisted in throwing Shingle bunds or embankments over the courses of numerous Channels that brought down during floods unnecessary supplies of water ~~upon the Kurdwar and Kurdhad branch, these works~~ and they did their duty very efficiently, ~~and they provided~~ by insuring the steady progress of ~~the means of carrying on~~ the excavations without any material interruption ~~during their progress~~. The ~~excavation~~ Channel which is excavated entirely through beds of Shingle ~~consisted~~ was of a Channel 14750 feet long, with a Slope of bed equal to 2½ feet in digging the initial depth ~~at the head of this Cut~~ was 3'.. 10" and the Slope is ~~carried on~~ uniform ~~from the head to the Cut directly upon~~ the Point established as Zero, or to the flooring of the Regulating Bridge at the Gunes Ghat. It was an object ~~a consideration~~ when laying out this line of excavation

excavation which passes directly
in front of the Pyri or main Ghat,
and the other Ghats and buildings
of the Town of Sundaw, to keep
the main Channel and the deep
excavations as far as possible to
the opposite side of the branch,
an arrangement that appeared
to me to be desirable both for
the purpose of preserving the
foundations from injury, and
for maintaining the water only
~~moderate depths~~ moderately deep at and in the
immediate neighborhood of
the Spots which were in general
use by the bathers.- At the
Pyri that the water is generally
shallow, but in many places
below this point ~~the water at~~ it
~~the foot of the Ghats~~ at the Town Ghats is so deep
as to be not only impassable
but actually dangerous for
those who frequent them ~~for the~~
~~purposes of bathing~~; at these
Spots the narrow Space between
the water and the buildings is
a bar to their utility as bathing
places for crowds of people. It
was proposed therefore to make
use of the Shingle taken from
the excavation in filling in these
deep and dangerous holes at the
foot of the Ghats, and to restrict
the depth of water along the whole
face of the Riverside of the Town
to 1½ or 2½ feet. This narrow
strip of shallow water, stretching
along the whole face of the build-
-ings both above and below the
Pyri or main Ghat, would during
the Annual fairs offer facilities
for ingress and egress which do
not at present exist, the deep
pools which now render bathing
dangerous would be removed,

and

and independently of the ad=vantages thereby gained to the community, additional security would be given to the buildings.

To those who are acquainted with Hurdwar at the period that I am alluding to, I need hardly observe that the Pilgrim in his ablutions at the Pyri Ghat is prevented from going to the right or left by the uncertain depths of the water, he must either retrace his steps up the Ghat, or cross the branch. The plan which has now been carried out might be still further improved by Establishing a barrier, an Iron Railing for instance, at a distance of 150 feet from and parallel to the Ghats, so as to prevent all pos=sibility of accident from the bathers wandering into the deep and rapid part of the Channel

The Main Current will necessarily be on the opposite side of the branch, and the bathing places will be restricted to comparatively Still water. Under this plan, in fact, although neither the Sanctity nor exclusiveness of the Pyri Ghat will be interfered with in the Smallest degree, the con=course of bathers will not after their ablutions are completed, be necessitated either to force their way back again up the Ghat, or to cross the River, but every facility will be offered for their escaping to the right or left and reaching the Town through the numerous roads and passages which connect the Main Street with the River face. The means of ingress and egress might be much improved

by

by the local authorities of the District, the passages down to the waters side might be maintained open, and free from impediment in the shape of huts, shops tem-porarily projected from the walls, and the heaps of rubbish which are allowed to accumulate in Native Towns; - wide roads or ramps might also be constructed both on the Northern and Southern extrem-ities of the Ghats: and as a still further improvement Bridges of Boats might be established across the stream, so as to connect the Ghats with the opposite is-land, and keep up a free communication which would be especially convenient at the time of the Annual fair.

At the Gunes Ghat the works which are immediately connected with Regulating the Canal supply, and delivering it into the Main Channel, have been constructed with due attention to economy; they consist of a Bridge with ten bays or Openings across the Mouth of the Canal with Shutters, each bay being 20 feet in width; a line of Re-tirement connects this bridge with a Dam which is built across the branch, and ~~which~~ is furnished with Sluices in its centre, and overfalls on its sides for the purpose of passing off floods: the design is precisely the same as only on a larger scale, than the Head works of the Jumna Canals, the principle being to maintain the supply which is brought down from the Main

River

River in a Reservoir ~~which is~~ subject to ~~open to it~~ regulation by a Dam, the water sufficient for the Canal supply passing down the Canal Channel through the Regulating Bridge whilst that which is superfluous is allowed to escape through the Dam Sluices. During the rainy months and when the supply in this Reservoir exceeds that which is required, or at periods when a necessity occurs either for laying the Canal dry, or for reducing its supply, the pur-=poses of the works are inverted, the Regulating bridge being either partially or perfectly closed and the Dam sluices being cor-=respondingly opened; the Dam in that case becoming the dis-=charge and waste escape for the water. A full detail of the construction of these works will be given in its proper place, the works themselves, however, are figured in Plate XIV. of the Atlas. On the right and up-=stream flank of the Regulating bridge, an arched passage for the admission of the Bochna Nulla, one of the mountain Torrents that I have before alluded to is pierced through a line of Revetment which extends upwards and is terminated by a ~~line of~~ Ghat or Flight of Steps resting on a Sweep of Revetment, ~~which in-=circles~~ whereby an old native building ~~to which it~~ is encircled and ~~affords~~ protection. The expense of these Revetments and Ghats became a heavy item in the ~~Estimate~~ Expenditure, the pro-=tection

=lection, however, which they pro=
=vided against the inroads of
the Stream, and the admirable
security which they offered both
to the Inlet of the Bochna Nulla,
and to the Native buildings
~~which~~ they were designed to pro=
=tect, rendered their construction
an useful appendage to the works
The Ghats, moreover, as offering
accommodation to Pilgrims
and others who visit Burdwan
and its sacred precincts, may be
received by the Rindoo as some
atonement for the liberties taken
with the Ganges, as well as with
the tutelary deity of the Ghat
upon the Site of which these
works were constructed.- The
Gunes Ghat of my original
Survey has now been converted
into an extended line of Stone
Steps washed by a running
Stream, and provided with Con=
=venient approaches for the ac=
=commodation of the bathing
community; Near the Site of
these works is a house built
for ~~the Bootie purposes~~ the European establishment, and other ac=
=commodation for Stores and
necessaries required for the use of
the works.- The Regulating Bridge
over the Canal, and a bridge
which is built over the Bochna
Nulla, afford the means of cross
communication between the
Towns of Burdwan and Kunkul,
~~which was~~ this being further facilitated
by the opening out of wide
and efficient approaches to the
Towns themselves

The depth of Excavation at
the

the point where the Canal Chan-
=nel commenced, and upon
which the Regulating Bridge
was situated was 22·83 feet,
the upper 17 feet consisting of
firm clay which rested upon
a Stratum of Shingle: the Ma-
=terial derived from this Exca-
=vation was used in forming
an extended platform between
the Bridge and the right flank
of the Dam; and the Shingle,
at least that portion of it which
was in sufficiently large boulders
to render it serviceable, was
used largely both in the found-
-ations and in the superstructure
of the works; at a date posterior
to the completion of the Regulating
Bridge, a great quantity of
boulders was carried away to
the different works which were
situated in the neighborhood
of Dowlaipoor and Bahadoorabad,
~~by which means~~ and the Esplanades
in the neighborhood of the
Dam and Regulator were thus relieved
from ~~a great quantity of~~ Materials
which useful as it was elsewhere,
was a disfigurement in its
original position, where it was
deposited in mounds occupying
~~a considerable Space of a Surface~~
grouped
which would have been much
improved by being perfectly level.
At the period however when
the water was admitted into
the Canal, and when the works
at this point were completed,
the esplanades in the neighbor-
=hood had been ~~relieved from~~ cleared of all
extraneous earth and Shingle,

and

and the difficulty of disposing of so much excavated matter, which in the first instance really appeared to be insurmountable was by the good management of the Executive Officer completely overcome.—

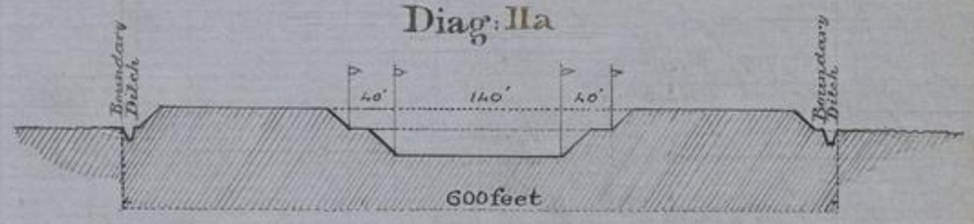
From the Regulating Bridge the Canal Channel leaves the bed of the Ganges; at this point therefore the work assumes an entirely new interest, and as I write these Chapters for the information and instruction of the Juniors in the Canal Department, and for the benefit of those who may be hereafter called upon to design and to execute works of a similar nature, I shall not hesitate, at the expense of being thought by the General reader somewhat tedious, to enter into a full detail of the progress, and of the deviations from the original Project, which time and a better acquaintance with the nature of the Mountain Torrents that we had to deal with, rendered necessary.—

~~It is unnecessary to~~ I think it better to avoid encumbering the text with the calculations upon which the Excavation and works were based, and which were given in appendix to my Report of 1815;—they will however be interesting to refer to, when the designs of the completed works are fully comprehended, and as ~~those calculations~~ these are in fact the basis upon which the whole structure has

has been raised, not only as re-
-gards the Canal views as a mere
Machine the parts of which
ought not to be subject to
disarangement; but as the
means of performing a certain
amount of Irrigating duties
the returns from which ought
not to be liable to disappointment
the appendix in Question has
been transferred as appendix F to the volume
of Tables, ~~to which place it~~ where it can be consulted by those
~~will be useful for reference.~~ interested in such details

From the Regulating Bridge
to a point 2 Miles below it, at
which a Bridge connecting the
Towns of Kunkul and Sowalapur
is situated, and throughout the
whole of which the canal ~~was~~
~~carried through~~ consisted of Shingle, the Slope of
the bed was determined at 24
Inches per Mile; in advance of
this Bridge the Soil was of a
lighter description and the slope
was reduced to 18 Inches; at
which it continued onwards
to Roorkee. - The Capacity of
Channel which was calculated
on this Slope, was fixed at a
bottom width of 140 feet, with
Slopes equal to $\frac{3}{2}$ of the depth
of Excavation; the Section of the
Canal throughout may be des-
-cribed by the following diagram

Diag: IIa



The Section above figured and
the Slopes above described will
be

be understood therefore, as those upon which the Works were be=gun and upon which the whole of the Channel from the Regulator at Mynapoor to the high land at Roorkee was originally projected.—

With these remarks as in=troductory to a proper understand=ing of the projected line of # operations from the Regulating Bridge downwards, I now come to the detail of the Channel from the bridge above mentioned to the Spot where it is crossed by the Rampoor Torrent, to within a short distance of which the Excavation had been completed as far back as 1826.— The Canal on this line ~~in the early part of its course~~ runs parallel to, and within half a Mile of a low Spur of hills which is thrown out from the Siwaliks, it leaves this Spur by a gentle curve to the right passing the Town of Kunkul on its left, and proceeding in a direction close to, and ~~to the~~ South of the Town of Jowalapoor reaches the neighborhood of the Rampoor drainage at a distance of 5½ Miles from the Regulator. On the whole of this line the slope of the Country extended from the hills towards the Canal, and it was necessary to dispose of the drain=age of this slope with as little interruption as possible to the Excavated Channel. There were three lines of drainage more or less defined, two of which were derived from the low Spur of hills along the foot of which the

Canal

canal was excavated, and the third was connected with the high levels above the Town of Dowalapoor. It was proposed in the Original project to adapt an Inlet and outlet to the Lounda Lenivala Torrent, which was the most remarkable one of the three, to give an Inlet to the centrical or Kumkul drainage, and allow the floods from this comparative =ly small line, to expand themselves in the Canal Channel; and to get rid of the Dowalapoor drainage altogether, by taking advantage of the slope of the Country, and turning it off to the Ramipoor Valley, by which it was supposed that efficient Relief would be obtained. -

The Lounda Lenivala Outlet was projected not only as an Escape for flood water during rains, but to act as a supply head for the purposes of the Town of Kumkul, and as the fall from the point of the Canal where the Torrent left it to the bed of the Ganges which was close at hand was considerable, it was proposed to build corn Mills near the junction, and to maintain this outlet as a supply head ~~also for them purposes~~ also

The Kumkul drainage was an ill defined hollow through which the Canal Excavations were carried, it was however of less importance than the former one. - At Dowalapoor there were no marks of drainage at all, the flood water appears to have swept over the Country and

and it was only when it found itself impeded by the Canal Embankments that it began to shew vigorous signs of active hostility; in the early stages, this hostility was confined to breaking through the Embank=ments, and cutting its way into the Canal by the formation of a deep Ravine; Subsequently, however, the floods effected a pas=sage into the Channel at the site of a Bridge that was built opposite the Town for the con=venience of the Inhabitants, and in so doing carried away a wing wall besides doing further injury to the Structure; free and open passages had up to this time been excavated for the purpose of carrying the water to the westward, but as they did not answer their intended pur=poses, and as other views with reference to the drainage were then in Contemplation, I deter=mined on making an Inlet opposite the Town of Powdapoor for the purpose of receiving the drainage water from that line of country. —

The Experience that had been gained by the deliberate observation for a number of years of the discharges and effects of the Lowndu Semi valla and Kunkul lines of drainage, had at this period thrown an entirely new light upon the method with which they also ought to be treated. The Canal Channel which as I have before Stated was

excavated

Excavated to a point near the
Ramjoor Torent, had for years
~~been in the habit of~~ received the
whole of the floods from the above
lines, with no further means of
outlet than an opening which had
been left in the Embankments
near Kunkul, this opening shewed
no signs of having passed off
extraordinary floods and the only
conclusion that could be arrived
at was, that the flood water of the
Loondu Leni and of the Kunkul
lines of drainage expended them-
selves over a very contracted area
of excavated Channel in which
they were completely exhausted.
The inlet, therefore derived from
these sources appeared to be of no
great consequence

For the protection however of
the right Embankment through
which this drainage had to pass,
it was thought advisable to build
Two Masonry works for Inlet, each
of these were 50 feet in width, the
design being similar in every res-
pect to that which was built
at Dowalapoor, viz: a flight of
steps or Ghat built to a sufficient
height to retain the maximum
high water in the Canal, and
strongly protected on the flanks,
to admit of the passage of the
highest possible floods.

The Escape on this line has
been limited entirely to one point,
situated just below the Town
of Kunkul, this outlet will
provide a head for Irrigation for
the Village of Kutarpoor and
others which lie on the Right
bank of the Ganges, and will

give

gine a supply to Clusters of mills which it is proposed to Establish on the lower side of the Town of Kunkúl. By this ~~Means~~ arrangement the necessity for Mills on the upper side as projected in the original Estimate in connection with the Lounda Lenilwala will no longer exist; and the inconvenience of having the old line of Channel ~~of the Lounda Lenilwala~~ which now runs through the upper part of the Town, as an open water course, subject during floods to heavy and dangerous supplies of water, will be entirely removed. It is evident in fact that the proximity of a Channel of this sort liable to sudden and intermittent discharges of water to a densely populated town is ~~not to be recommended~~ open to serious objections. From the arrangements now made, it will cease to act as a line of water course at all, and I have no doubt that in a few years, all vestiges of its existence will be lost.

Between the Myapoor Regulating Bridge and the Ranipoor Torent, the following works have been constructed

2 Bridges for Cross communication
One at Kunkúl, the other at Dowalapoor, the latter including the works at the head of the Ranjolla
1 Outlet on the left bank - South of Kunkúl -
3 Inlets on the Right bank { Lounda Lenilwala / Kunkúl / Dowalapoor

The Excavation on this line of Channel with the exception of that point where the Kunkúl drainage crossed it, and which was ~~only~~ 990 feet in length with an average

average depth of digging of 5 feet only, was very great: on 2 miles of its course it averaged 22 feet, elsewhere from 15 to 18 feet, the maximum depth being 25·08 feet from the surface; throughout the whole line the soil was good with a large admixture of clay, and, as I have before said, from My apoor to the Kun Kul bridge the Canal bed was excuted in shingle. —

The left bank has been formed into a wide and spacious roadway which is continued from the Myapoor Regulating Bridge to the 1st class Chokí at the Rani=poor Works; this road acts as a line of patrol for the canal Es=tablishment, and is in fact a good carriage road for every purpose that could be required. The right bank as will be inferred from the system of Inlet which has been above described, is broken at three different points, and it has not been considered worth while to complete the line of commu=nication by throwing supranches over these Inlets, or to make any arangements for clearing and maintaining a passage along this Bank further than will be provided by the interior berm. It is supposed that the scale upon which the works have been built for the admission of Inlet water and which ~~has been determined on the experience~~ is the result of 12 years of observation, will place the banks on the right of the canal out of all jeopardy. —

The Changes that have taken place

place in the distribution of works on that portion of the Canal be-=tween the Myapoor Regulating Bridge and the Ramipoor Torrent, consist it will be observed of in-=creased Inlet to drainage water on the right, and to decreased out-=let on the left; the causes for such changes have been described, as arising from the observed quantity of flood water in the Loondu Leni and Kunkúl lines being less than it was originally estimated, and from a disinclination to interfere with the Town of Kunkúl, by in-=troducing into its precincts an Element of such danger, as an open Channel subject to Sudden and impetuous discharges of flood water. The additional Inlet of the Towala-=poor drainage was proved by deliberate and anxious experiment to be absolutely necessary for the convenience of the Town: there were other reasons which will be hereafter explained why the relief of the Country at this point, and by the method adopted, was con-=sidered to be expedient.

From the point of the Canal where the excavation of 1856 ter-=minated, or from a point situated immediately above the Ramipoor Torrent, the line upon which the Canal Channel has been excavated and the works ~~have been~~ built, is one of very peculiar interest. it is that upon which the works have been subject to the greatest changes from the original design, and it is one, where the circumstances under which the Canal Channel is brought in contact with Torrent

deserves

deserves the marked attention of all those who are interested in & Civil Engineering under difficulties

To enable me to place the & details with any degree of perspicuity before the reader, it will be necessary to bring under review the whole of the country lying between the Ramipoor and Rutmoo Torrents, including the drainage which gives rise to these Torrents; to explain the project for passing the Canal through this line of country as designed in my report of 1815, and to shew the causes of the changes that have been & made in that project ~~during the execution of the works which have been actually executed~~ The total length of Canal Channel which will be embraced in this review is equal to 8 Miles. —

By referring to Plate III. of the Atlas which exhibits in the greatest detail the Surface Profile of the country, and which is in fact a contour of the whole of the land lying between the Mountains and the Canal, a good general idea of the circumstances under which the works were placed will be obtained. It is desirable that these general features of the country should be understood before the details of the Canal Operations are considered, as ~~they are~~ they exhibit peculiarities ~~somewhat similar attending upon them~~ to those of ~~as there were in~~ the country passed by the line of the Eastern Jumna Canal, amongst which may be noted the very remarkable one of double slope, which may hereafter in all probability be taken advantage of

of with great benefit to the ~~Ganges Canal~~ works.- In the present instance the slope in question proceeds from East to West, instead of from West to East as it does in the drainage on the Western water shed with which the Eastern Jumna Canal works are connected: in both cases it has afforded the means of projecting a line of Canal on slopes sufficient for the purposes required, and in both cases it has placed in our hands the ability of re=gulating the distribution of the flood water; I have in a former Chapter explained how beneficially this natural arangement of slope combined with topographical ad=vantages from which I am sorry to say the Ganges Canal works are entirely precluded, has been brought to bear upon the line of the Eastern Jumna Canal, in relieving its works from the effects of Mountain Torents, and although I see no probability of free-ing the Ganges Canal works altogether from flood water, in the way that the Mushuma on the Eastern Jumna Canal has been freed, by Escapes into Rivers which are entirely unconnected with the works; we hold in our possession the means as I before said of regulating its distribution, and as I have in some degree made use of the means thus placed in our power; it may be as well to lay some stress upon them here preparatory to the de=tail which will ~~hereafter~~ follow

The remarkable points in the Country which I am about to describe, as connected with the

Canal

Canal works, were, 1st: the extra-ordinary slope upon which the Mountain Torents (which crossing the line at right angles to its course) passed onwards to the lower levels of the Khadir; 2nds the peculiar circumstances under which the beds of these Torents exhibited themselves, or more properly speaking did not in some cases exhibit themselves at all; and 3rds the alluvial nature of the soil, with a disposition of spring water which as leading to complete drought in one, and complete saturation in another part of the line, was particularly inconvenient.-

The line of Canal in proceeding across the Ramipoor Torent onwards to the Rutmoo, gains in departure from the Hills considerably; at the point where it crosses the former River the Hills are at a distance of 2 3/4 Miles; half way on its course, or at the point where it crosses the Puttri, it is 5 1/2 Miles distant, and at the Rutmoo the distance has increased to 16 Miles:. this is a Question of some importance in estimating the value of the flood water.-

It was proposed in my project of 1845 to adopt the Dam System, as practised on the Summa Canals, for all the Torents, the courses of which were intersected by the Canal Channel; to confine the Masonry works to Outlet only: to dispose of the superfluous fall of Country by masonry descents, and to reach the Rutmoo

Dam

Dam by a gentle sweep, from the termination of which, the bearing on Roorkee would be in one ininterrupted line. —

The Country to be passed may be thus described. The Ranipoor Torent which is the first defined line of drainage west of Sowalupoor, is directly connected with the mountains: its Catchment basin may be estimated sufficiently accurately for our purpose at 45 Square miles. from its debouche from the Mountains to the point of intersection with the canal, the distance in a direct line is 2 3/4 Miles, which by the tortuous course on which the flood water runs may be increased to 4 3/4 Miles: the total declivity of bed on this line is equal to 87.1.9" or 18.3 4 feet per Mile In my original Survey of 1839/40 I remark that at a point 4800 feet below that where the canal intersects the line of the Ranipoor Torent the water spreads over the surface of the Country, leaving no trace of ~~a water course~~ defined channel; the average width of the bed of the Torent was at that time 100 feet, and borings which were carried on in the bed at the point where the canal works were to be constructed shewed at 3 different places, that there was favorable soil at a depth of 14 feet from the surface; the borer, however, shewed no signs of Spring water at a depth of 40 feet; at half a Mile to the west and immediately on the edge of the high bank skirting the Torent, the ~~Surface~~ Gaol

of

of the water in the Moongawala
well was 60 feet from the Earth's
surface. The supersoil in the well
was pure sand; at the depth above
mentioned of 14 feet this was of a
better consistency and mixed very
sparingly with small shingle.
but to the extreme depths reached by
the borer ~~arrived at~~, the soil pro=
=duced was merely sand more
or less mixed with clay. Im=
=mediately at the point where
the Canal and Torrent came in
contact, the latter had within
the last few years deserted its
direct course towards the village
of Surai and had made an
abrupt turn to the westward,
on the bearing in fact upon
which the Canal was to be carried.
this abrupt turn had excavated
a deep channel close under the
Moongawala well, the position
of which at that period was one
of great jeopardy; another &
equally sudden turn to the South
had thrown the direction upon
the village lands of Boungla
~~upon which~~ where the flood water ex=
=hausted itself, leaving as is
usual in such cases sandlike
deposits of Sand. The site of the
works was, therefore, at the head
of a Delta, the Eastern branch
of which ran in prolongation
of the Rivers course on its approach
to the works, and bore on the village
and lands of Surai; the western
turned off abruptly to the Boungla
lands. The position determined
upon for the Dam was on the old
or easterly branch, which it appeared

from

from the Revenue Surveys of 1835 (only 14 years before the date of my examination of the Country) was the line of Torrent at that period.—

I have before noted that the slope of the Country from the debouche of the Torrent from the Hills to the point of intersection of the Canal Channel is 87.1.9 or 18.34 feet per Mile. below this intersection on a distance of 2½ Miles the slope was 40 feet, or 16 feet per Mile - The effective slope or that in immediate Contact with the line of Canal as shewn by Fig. 1 in the accompanying Sections, was equal to 15½ feet pr. Mile; one third of the length upon which the Section was taken being above, and two thirds below the line of works.—

The Sill or flooring of the Dam on this project was 12.725 feet below the surface of the bed of the Torrent. The inlet was designed without Masonry works of any description, and the outlet or Dam on the left bank of the Canal ~~as~~ (purposely) ~~mitted a discharge~~ a waterway over the piers heads of 131½ feet in width, the sluice openings being ten in number and each of them ten feet wide. I have before explained that on the project of 1845, the works of which I am now describing, the slope of the Canal bed throughout the Khadir was 18 Inches per Mile, it will therefore, be understood that the different points of fixed level for the sites of Dams are determined

=mined on this particular slope, the intervention of descents a falls for overcoming excess of slope being duly considered.

In advance of the Ramipoor Torrent and its watershed, the rapid fall of country, which led to the Valley of the Puttii Torrent was overcome by descents in Masonry of 8 feet each, either collected in one spot, or divided into two separate descents, as the levels of the actual line upon which the Canal would be excavated, might prove to be most convenient. These descents were to be passed by Lockage for which provision was made in both plans and Estimates

The Puttii ~~Valley~~ drainage as I have formerly said may properly be brought under two different heads, viz: that portion of it which was connected with the mountains, and which may be called the "Puttii Proper," and a tract of country lying to the Eastward in the neighborhood of the Town of Selimpoor, which extending over an Area of about Ten Square Miles, had its drainage confined within a distinct although ill defined watershed, consisting of grass and jungle land extending towards the mountains, ~~by the~~ the water from which, excepting in very high floods, it was totally unaffected. The material difference that existed between this jungle ~~Plain~~ drainage and that of the Puttii Proper was that its flood water was entirely free from sand

Sand and Silt; its course was marked by deep ravines and a well defined section both to the North and westward of the Town of Selimpoor; at a point about half a Mile South of the Town no traces of this drainage were ~~visible~~ to be seen, the surface of the country was under cultivation and there were no outward and visible signs, by which a person who had confined his examination ~~of this part of the country~~ to the line of the Canal alone, could have formed an idea of the nature of the drainage over which he was passing: At this point the project of 1845, gave a design for works similar but on smaller dimensions to those at the Ramipoor Torent. the water being admitted through the right embankment by an opening left for the purpose, and a Masonry Escape of 20 feet waterway being constructed on the left for ~~the purpose of~~ passing the flood water out of the Canal —

The Puttri proper which, like the Ramipoor Torent, is connected directly with the Mountains, was marked at the point where the Canal intersected its course by sheets of Sand, elevated rather than depressed below the surface of the Country, and with no signs of excavated Channel; the Channel in fact appeared to cease at about a Mile above the point where the Canal ~~Chan-nel~~ had to cross it, and at this

point

point of cessation the sand was
thrown over the surface of the Country in the
same fan like expanse, that
had shewn itself to me at
Bounglu and Surai when ex-
-amining the peculiarities
of the Ramipoor drainage. -
The catchment basin of the Puttio
valley may be estimated at 80
Square Miles: from its debouche
from the Hills to the line of Canal
the distance in a direct line is
5 Miles, its course, however,
is an exceedingly tortuous one.
- its main branch leaves the hills
considerably to the Eastward, and
after skirting the foot of the moun-
-tains, and gathering in its passage
the drainage of the different valleys
with which it comes in contact,
it takes a direction almost due
South, and with the exception of
a few twists characteristic of
this species of River, passes the
line of Canal on a tolerably
direct bearing; the defined
section which marks the earlier
part of its course losing itself
as I have before described over
the surface of the Country. On
this tortuous course the distance
between the points above men-
-tioned may be Estimated at 6½
Miles, the greater part of the
Country over which it passes
being Forest and uncultivated
land. The total declivity of
bed from the Hills to the point
of Canal intersection was 179.6.5
or 27.6.2.5 feet per Mile. From
this point to a distance of
11500 feet South where there are

Marks

marks of the commencement of a well defined although narrow section, the slope is 9·8 feet, or nearly 25 feet per mile. The effective slope or that in immediate contact with the Canal as shewn by Fig 2 in the accompanying sections was equal to 25·41 feet per mile; One third of the length on which the section was taken being above, and the remaining two thirds being below the line of works

The Sill or flooring of the Dam on this project was 9·57 feet below the surface of the bed of the Torent, and the arrange=ments for Inlet and Escape were precisely of the same dimensions and projected on the same design as those at the Ranipoor works

As a further means of dis=posing of the flood water of the Puttri Valley, a Dam and Escape similar in every respect to that at the Selimpoor line of drainage was projected close upon and under the ridge upon which the Town of Gurh is situated, this ridge being the westerly watershed of the ~~Valley which constitutes the~~ Puttri Basin ~~drainage~~

The Valley of the Puttri there=fore was under the project of 1845, provided on the left bank with three separate lines of Escape; that on the East passing off the Selimpoor drainage, that on the west giving a relief to the floods from the high lands near Gurh; and a main central line pro=vided for the especial purpose of the Puttri Torent itself; the

total

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Dieug: III.

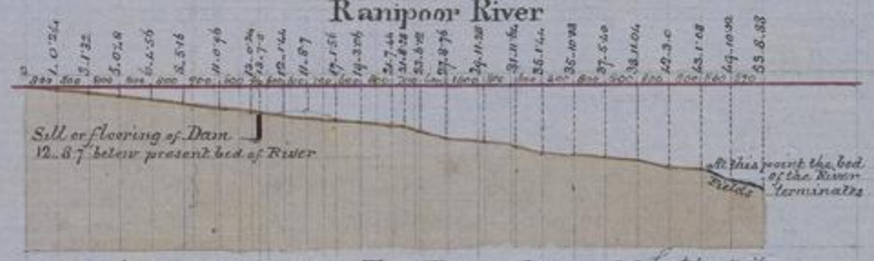
Sections on the Ranipoor, Puttri & Rutmoo Rivers

Shewing the declivity of Bed as connected with the

GANGES CANAL WORKS

Fig. 1.

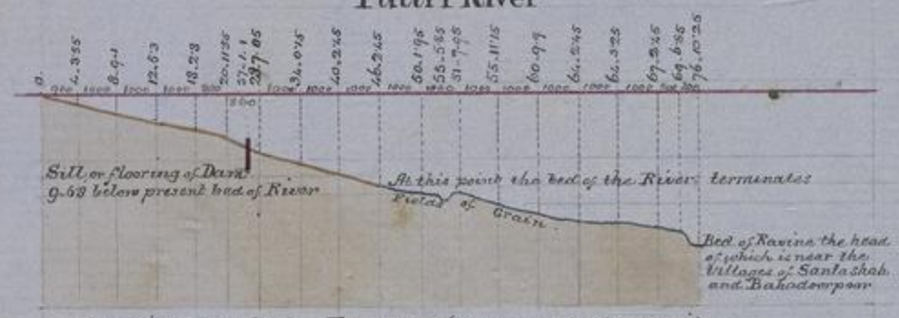
Rampoor River



Length 3m. 3 Fur. and 150 yds. Total Fall 53..8.28 or 15.5 feet per mile

Fig. 2.

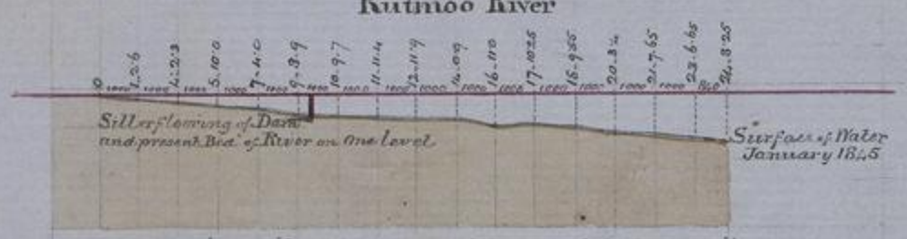
Puttri River



Length 3 M. 1.0 Yards Total Fall 76.10.25 or 25.1 Feet per Mile

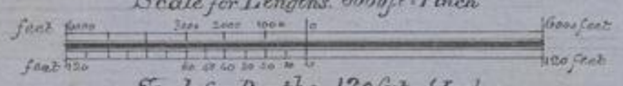
Fig. 3

Rutmoo River



Length 3 Miles Total Fall 24.3.26 or 8.23 feet per mile

Scale for Lengths. 600 ft - 1 inch



Scale for Depths. 120 feet - 1 Inch

total width of waterway that these 3 escapes afforded was 1150 feet between the piers of the Dams with a flush passage over their pier heads of 178½ feet. Openings of equal dimensions were to be left on the right for the admission of flood water.—

On leaving the Puttri valley and after crossing the Ridge on which the Town of Gurh and Vilage of Saynibas were situated, at which point it was proposed to build a bridge for cross communication, the line of Canal, as I have before noted, on a slope of 18 Inches per Mile, comes in contact with the Baushahpoor Nulla, a sharply cut Ravine in which there was a perennial stream of water tributary to the Rutmoo River;- the head of this Nulla was situated at a distance of 1 Mile North of the Canal, and the level of Spring water afforded a fair indication of the State of the Springs in its neighborhood; the Canal bed crossed this Stream at an Elevation of 5 feet above the waters surface: there were no works estimated for on this drainage, the question of Inlet or Outlet being left an open one.-

From this point the Canal Channel was ~~proposed~~ to be carried on a gentle Sweep upon the line of the Rutmoo River, the levels of which it reaches by descents of Masonry equal in extent and dimensions to those which were proposed at

Bahadoorabad

Bahadoorabad; at this point also a navigable line was pro-
-jected round the falls for the passage of boats and rafts.-

The Rutmoo River or Torent it will be understood from the foregoing description, runs on a level considerably below the high land on which the canal ~~in its approach~~ hitherto has been carried; the Valley through which it takes its course is at the point of contact with the canal about a mile in width, bounded on the right by a steep and precipitous bank on which the Village of Peeran Kulleem, with its Tombs and Dirrgahs are situated.- The Catchment basin of the Rutmoo Torent may be estimated at 126 Square Miles 36 of which lie in, and 90 at the foot of the mountains- The Valley above the canal works re-
-ceives the whole of the drainage from the Kamsrao and Sukrouda Forests combined with that which pours down from the mountains ~~from~~ by the different Ravines and passes on a length of 10 miles; its Water shed on the East is bounded by that which falls off towards the Puttri and on the West by the slope which delivers the drainage upon the Solani River- The ~~Tor-~~ -rent debouches from the hills of the Torents which are tributary to the Rutmoo ~~va~~ from 10 to 16 Miles from the Canal Works: the main or Westerly line of drainage being the most distant The greater portion of the Country

over

over which these tributaries take their course was at the period of my original Surveys Forest and grass jungle, the few villages that existed being mere hamlets, with a field or two in their immediate neighborhood - From the point where the main branch of the Rutmoo left the Hills to the bed of the River at the intersection of the Canal line, the slope was 626'. 11'2". or averaging 39'18 feet per Mile: below the point in question this slope decreased; but the effective slope or that in immediate contact with the works as shewn by Fig. 3 in the accompanying Section was 8'23 feet per Mile, one third of the length on which the section was taken being above, and two thirds being below the line of works

The Sill or flooring of the Dam on the Rutmoo River, coincided with the natural level of the bed, and the arrangements for Inlet and outlet were on the same plan as those that I have before described, viz^t. Masonry Sluices on the left for the purpose of passing off, and an open breach through the right embankment for admitting flood water. On the right of the valley ~~drains~~ a masonry drain was designed ~~were proposed~~ for carrying the water of the Bhuguleea, (a little stream or Nulla that runs at the foot of the Peeran kulleem bank) under the Canal Channel, so that inundation which would necessarily arise where the course

of

of the stream was interupted by the Canal Embankments, might be prevented, Attention was also drawn at this time to the inundations consequent on the Canal bed, and that of the River being on one level. It was observed that under this circumstance the maximum head water in the Canal which is proposed to be 10 feet from the Sill of the Dam, and therefore from the bed of the River, must stand in back water, forming an inundation on the upper side of the Dam; by which not only would a serious disfigurement arise to the works, but the rank vegetation consequent on inundation extended over such a large surface, would in all probability affect the health of the neighbouring population, as it would inevitably provide a harbour for Tigers and other vermin. The evils of a large inundated tract at this point were undeniable, and although I proposed a method for curtailing this evil, which was the least expensive that could be devised, I suggested at the time, that it was by no means improbable that during the operations in this valley, other and perhaps better remedies might offer themselves. It was natural in fact to look to the system of Tunnelling which had been proposed for the Bhuguleea Nulla, as one equally appropriate to the relief of the Rutmoo inundation.

The works proposed in my Estimate of 1845 for the Rutmoo River consisted of a Dam with 40 Sluices of 10 feet wide each,

and

and plank Sluices ~~of~~ each 100 feet in ~~width~~ width ~~each~~, The flush passage over the pier heads which ~~was~~ 10 feet above the level of the canal bed ~~being~~ was equal to 796½ feet.—

A Bridge for the purpose of regulating the canal supply and for preventing the floods of the Rutmoo from passing down the canal, was ~~proposed~~ to be con-structed across the canal chan-nel between the River and the Peeran Kulleem ridge; the design of this work with its arrangements for regulating the supply were similar in every respect to that at the canal Head ~~at Nyapoor~~.

Having now passed over in detail the country between the Ranipoor and Rutmoo Torents, having described the slopes of country over which the line of canal had to take its course; and having noted its relative position to the mountains; we may in adverting to the different works which were proposed at this period for overcoming the difficulties which were offered by the Mountain Torents, point out the comparative want of information that we pos-sessed at the time in question, to that which we held at a later period. The Surveys upon which the whole design of the Ganges canal was based, were made by myself unaided by Staff of any description, and were carried on at a time when my attention was divided by the responsibilities of other duties. ~~These duties~~ which neither permitted a pro-longed absence from them, nor of any interruption at all to the daily

daily routine of office business. I was therefore necessitated to confine my views to the determination of a line for the Canal, and to the examination of the Torrents in their immediate connection with it; to the details in fact which are given 'in extenso' in the report of 1845, from which the whole of the data, ~~which~~ I had at that time in my possession, and upon which the project was formed, ~~and which are~~ This report is open to the perusal of all who may take any particular interest in the subject.-

The valuable information which we have since gained by the numerous, and I am by no means disinclined to allow, the fortunate delays that have taken place in the prosecution of these works, has shewn ~~placed~~ the character of the mountain Torrents in a very different aspect ~~light~~ to that in which they were originally displayed ~~was originally estimated~~: the deliberate Surveys and Contour levelling which have been carried over the whole of the Country between the Hills and the line of Canal, have thrown ~~a~~ light upon the subject of the drainage of which we were previously ignorant; and it is not too much on my part to claim some indulgence ~~consideration~~ for a design projected on limited data, and unaided by those advantages which time and experience have since accorded to us

In recapitulating the works above described, it will be observed that the Section of the Canal Chan-

-nel

=nel was continued on the same dimensions as are shewn in Dia=gram II; the slope of the Channel was ~~continued~~ maintained at 18 Inches per Mile, with a superfluous ~~fall~~ slope of 32 feet disposed of in Masonry descents; that the Cross drainage was to be effected by gaps left in the right bank for the admission of flood water, and by Masonry Works, with sluices adapted to escape ~~attached~~ to the left ~~bank~~; ~~and that~~ The total Amount of Waterway which was allowed for Escape under this project was equal to 1106½ feet distributed as follows:—

Ranipoor Torrent = 131½ feet above pin heads
Puttri as { East 23½ " do / Total 178½
Centre 131½ / West 23½ " as }
Rutmoo as 796½ " do

It must also be remarked that the Canal bed came in contact with the Torrents under the follow=ing circumstances

Ranipoor Torrent bed 12'7½ above the Canal bed
Puttri as 9'5" as
Rutmoo as On the same level

and that the projection of the levels of the canal bed, and the position of the Falls or descents of Masonry had been devised, not only with a view of reducing the difference of level between the Canal bed and that of the mountain Tor=rents to a minimum, but re=stricting the excavation of the Channel to moderate depths, and thereby escaping the Springs which shewed themselves on the Country between the Puttri and the Rutmoo valleys. The Bridge between Symbus and Gurh was the only work for cross communi=

=cation

-cation that was contemplated on this line of the Canal.-

An attentive perusal of the above recapitulation, with the matter that has preceded it, will, with plate No III of the Atlas before him, put the reader in a position to form his own opinion as to the value of the inductive reasoning which led to an extensive revolution in the method originally adopted for dealing with the Ramipoor and Puttri drainage. This involved a material change in design for the disposal of the flood water; ~~and, consequently, to an extensive~~ ~~with~~ modifications to the disposition of Slope in the Canal bed; and in some cases an increased capacity of Channel.-

The views which I entertained on the subject of the effects of the Ramipoor and Puttri Torrents upon the Channel of the Canal at the point of contact, may be best shewn by an extract taken verbatim from my report of 1845 After explaining the position of the Ramipoor masonry Dam, and other points with regard to levels, with which I have before made the reader acquainted I observe "The "Masonry Work being completed (or "during the time of its progress "if Labores are to be procured in "Sufficient abundance) the Excavation for the Escape at the Dam "tail ought to be commenced, "this I propose shall consist of a "Channel fifty feet wide with "its bed formed on a declivity "of 2½ Inches per Mile, which "with reference to the actual Slope "of the Surface of the Country, will

at

"at about 6 or 8000 feet South deliver
"the escape into the low land
"draining itself into the Ganges in
"connection with the Puttie River.
"the width of channel proposed
"will be sufficient to enable the
"stream to adapt itself to its
"own wants, by clearing out a
"passage suited to the body of
"water which will be passed over
"the Dam. - North of the Dam" and
to this point I would draw particular
attention" and up the course of
"the Ramjoor Rao, the bed of the
"River will be deepened so as to
"meet the level of the Canal bed
"on an inclined plane the base
"of which shall be half a mile
"I propose that the width of this
"excavation should be 40 feet. -
"It may be assumed that during
"floods, the Canal which crosses
"this River at right angles, and
"which will receive in the first
"instance all the water which
"comes down the River, will hold
"from 6 to 10 feet of water in depth,
"so that a considerable backwater
"will be present to receive the
"floods that come down the Rao,
"and the meeting of the flood
"with the Canal back water will
"in the case of the depth being
"6 or 10 feet, take place at a distance
"from the line of the Canal and
"the Masonry Dam - The wear
"and tear to the bed of the Rao,
"owing to this alteration of its
"levels, will necessarily lead to
"the removal of Sand and Silt
"all of which will be borne for-
"wards in the direction of the Canal
"a portion of this, will necessarily
pass

"pass off through the sluices of
"the Dam ×, but owing to the
"canal stream meeting that of
"the Rao at right angles to its course,
"a portion will be projected into
"the Canal Channel: the Dams
"and Escapes which are situated
"lower down the line will, however,
"in some measure act as a relief
"to this inconvonience, and the clo-
"sing of the Regulating Bridge South of
"the Dam on the Rutmoo River
"will in all probability act as
"the means of efficiently scour-
"-ing the Canal Channel through
"the Sluices of the Dam at that
"point – it is to be understood
"that with the exception of the
"periodical floods which usually
"occur during the rainy months
"only, the beds of these Raos are
"perfectly dry. The Silt, therefore,
"obtained from these sources is
"merely an occasional evil".-

The plan of the inclined plane or rapid, by which the water from the Torrent was to be admitted into the Canal Channel, was evident-ly a crude and imperfect one, it brought into direct contact two slopes on extreme declivities, and was in fact the introduction of an evil in somewhat of an ex-aggrated form ~~of~~ like that with which experience had made us acquainted elsewhere; it will be understood however from the extract above given that the body of water and current which the Canal was supposed to deliver at right angles to that of the Rao would project a great portion of the Silt forwards in the Canal Channel out of which it would find an

exit

exit from the lower Escapes, whilst the remainder would pass over the Outlet made expressly for its ~~Reception~~ passage. The remedy, however, was in itself one of great incon-=venience, to say the least of it, and it was one that had suffi-=cient objections, to render any de-=pendence upon it a matter of very questionable propriety.

On my return from England and reassuming charge of the works early in 1848, the whole question of the drainage on this line of Country, was one of the first that occupied my attention. the foundations of the Ranipoor Dam or Outlet were at this time in progress, and by the Month of July of that Year had been com-=pleted; during the progress of these operations, and during the rains of 1848, the floods were passed round the works by ~~the Establish-=ment of~~ well protected Embankments and it was at this time that the enormous accumulation of Sand which these ~~Obstructions~~ Embankments led to, be-=came an object of prominent observation; the floods during the Rains of this season had been numerous, and in the Month of July one of the heaviest that had been experienced poured down the River, the protective arrangements to the Masonry works, however, did their duty efficiently.

After the Rains of 1848, the Ranipoor River and the drainage connected with it, were ~~the subject~~ subjected ~~to~~ to a more detailed examination, than they had hitherto experienced,

and

and in the Month of Febuary
1819, after drawing the attention
of the Government to the acknow-
=ledged imperfections of the admis-
=sion of the Rao water into the Canal
Channel by an inclined plane
excavated through the bed of a Sandy
river; I pointed out the only remedy
that appeared to me to be available,
viz: the substitution of a masonry
Overfall for the inclined plane,
by which the levels of the Ramjoor
bed would be in some measure
retained on their original level.
The advantages anticipated by this
plan were

1st Great relief to the Canal Chan-
=nel from silt and gravel from
the influx of a Torrent running
on a Sandy bed under a great
slope.

2nd Security to the Embankments
in the neighborhood

3rd Advantage to the cross com-
=munication of the Country, by
retaining the bed of the Rao
or River on the higher level, by
which means the Road between
Hurdwar and Saharunpoor
which lies immediately on the
North of the Canal ~~would~~ be
maintained passable during
the year.

The actual state of the
works at this particular point
were on the date above noted as
follows:- The Excavation of the Canal
Channel was in progress across the
bed of the Rao, a bar of Earth
having been left across the Chan-
=nel at the point immediately
above that where it came in Con-
=tact

=tact with it; the flooring and foundations of the Dam were laid bare and the Escape channel was nearly completed; the foundations of the Inlet to which I have above alluded were in progress, and a sufficiency of material had been collected to complete the work. In a report at this period I concluded my remarks by observing that "I look confidently to seeing the "whole of these works completed "(with the exception of the Dam "piers the completion of which is "postponed) before the next rains. "I am anxiously desirous that "such should be the case; that "we may in these works gain "some practical experience, and "consequently useful hints for "the execution of the works on the "Puttiv drainage, the site of "which is a few miles below the "Ranipoor Rao."

The design of the Inlet (Plan and section of which will be found in Plate No XV of the Atlas) was a plain perpendicular drop of 10 feet, with a reservoir at the foot to receive the water; the flanks were well protected by + Masonry wings, which were covered on the ends ~~which~~ resting on the Embankments by piling; the Sill of the Overfall was 2.72 feet below the level of the bed of the River, the height of the drop being designed with reference to the estimated high water mark in the Canal which agreeably to the Project was 10 feet.—

The whole of these works were

Completed

completed before the rains of 1849, with the exception of the Piers in the centre of the Dam waterway. The Escape from the Dam had been entirely cleared out on a width of 51 feet, with a slope of bed equal to 4:75 feet per mile and bunds or Embankments had been thrown across the Canal Chan=nel both above and below the works, so that the Torrent might be con=fined to its own course, be allowed and not to interfere with the Canal Excavation on the right or left. Under these circumstances the works were opened for the passage of the River.

That the effects upon these works which I am now about to describe may be fully understood, I may observe in this place, that the slope of the Inlet was equal to 10·33 feet in a length of 14,00 feet or 38·95 feet per Mile - whilst that from the tail of the Inlet along the line of Escape which had been pro=vided for it was equal to 4:75 per Mile or 6·12 in 6800 feet; the width of the Torrent might be on an average 100 feet, whilst that of the Escape was 51 feet only.

After a flood which occured on the 19th June 1849, the Canal bed at the foot of the Inlet had upon it a deposit of 3 feet of Sand, eight floods ~~which succeeded the former which was somewhat severe and which occurred~~ occurring on the 25th and 26th of the same month raised this deposit 2 feet, making a total depth of Sand at the foot of the Inlet equal to 5 feet; During the

Month

Month of August following a succession of floods still further added to this accumulation of deposit, until at the termination of the rains, neither Dam nor Inlet (with the exception of the upper portion of the flanks of the latter) were visible; they were to all intents and purposes buried, and the bed of the River had formed itself on a natural slope entirely independent of the works which we had constructed for its accommodation. A perfect detail, both in plan and section, of the State of the Ramipoor Ter=rent before and after the rains of 1849 will be found on the opposite page. The results, in the very rapid extent of deposits, were by no means anticipated; the slope upon which the Escape was designed was, it will be observed, very considerable, and al=-though the Comparative width of this Escape was small and might in some degree add to the evil already existing of the capabilities of Inlet and dis-charge not being in equilibrium either in slope or Capacity of Channel, I con=-sidered that the nature of the Current acting upon a soil of a light & sandy description would by widening out the artificially excavated Channel, dispose in some measure at least of these difficulties, ~~and although~~ It was not overlooked that deposits would necessarily take place upon the line of Channel South of the Masonry Inlet, but it was considered that these deposits would be of a

Nature

nature, that would render their
periodical removal, a matter of
little difficulty; and that in fact
when the Canal was opened,
and the cross current which it
would give rise to came into
action, that the interference from
these deposits would be of no
consequence at all. —

Now the effects that are above
described, are by no means dis-
-similar to a re-disposition of
sand on natural slopes which
occurred in the Nogong River,
one of the Torents connected with
the Eastern Gumma Canal, and
as the case in question is exceed
-ingly illustrative of the change
-able nature of these sandy beds,
and of their disinclination to be
interfered with, I shall make no
apology for introducing the sub-
-ject here. —

The Nogong Dam is a masonry
building constructed across the
bed of ~~the~~ Torent, which has a
Catchment basin of about 56
Square Miles, 25 Miles of which
are mountain, and the remainder
open forest and jungle country
lying at its foot. The Dam it-
-self is situated at a distance
of 7 Miles from the Hills, and
the slope of the bed of the Torent
at the point upon which the building
was constructed, was 11½ feet per
Mile: there were 24 Sluices of 7
feet width each adapted to the
centre of the Rivers course, the
8 Centrical ones having their Sill
or flooring 2 feet, and the side
ones having their Sills 4 feet above
the bed of the River; the piers of
these

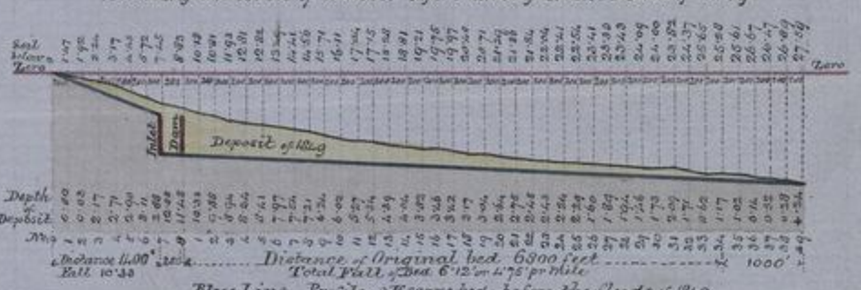
Diag. IV

Sketch of the Ranipoor Rao as connected with the Ganges Canal

Scale 1200 feet to One inch

Section on the Ranipoor Escape

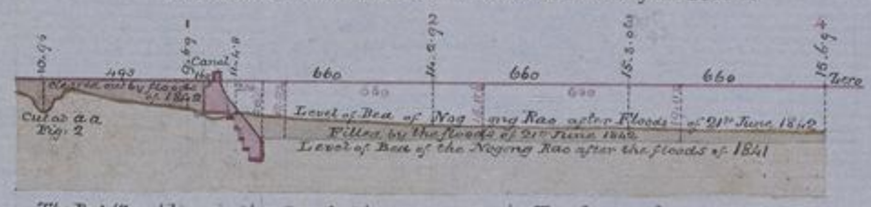
Shewing the levels of the bed before and after the Rains of 1849



Diag: V

Fig: 1.

Section across the Dam down the Bed of the River



The Red 'Zero' line in the above Section represents the True Level of the Canal bed and that of the River in 1828/29 when the Nogong Dam was constructed.

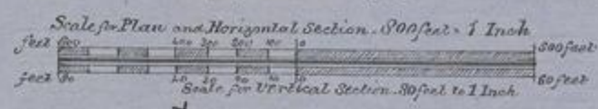


Fig: 2.

Survey of the Nogong River as it existed after the destruction of the Dam, shewing the Canal Stream turned down its new course into the Belka Cut

a. a. — a' a' Bund built after the destruction of the Dam to turn the Canal Water into the Belka Cut.

Fig: 3.

Longitudinal Section through Nogong Dam (Old)

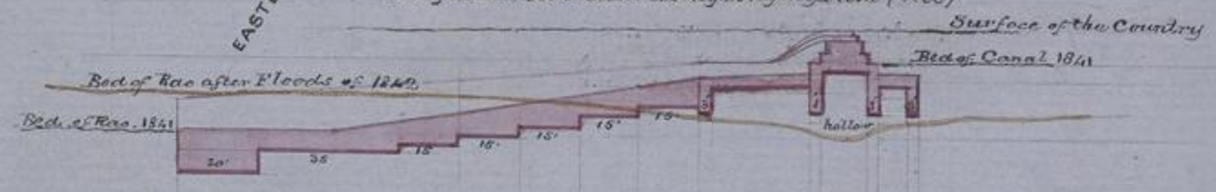
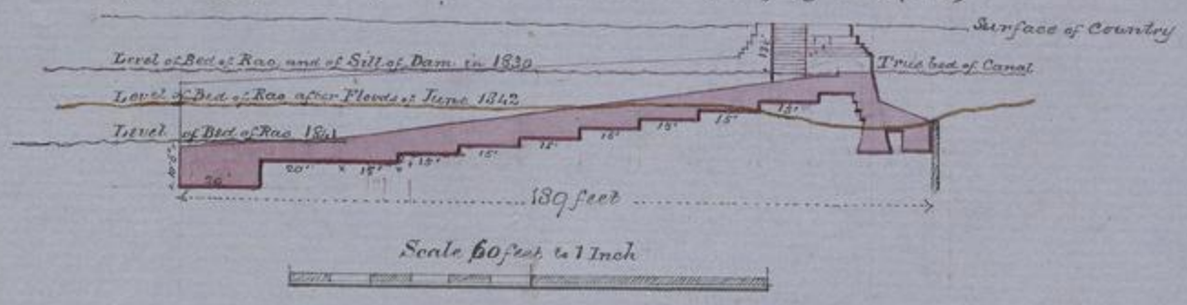


Fig: 4. *Longitudinal Section through Nogong Dam (new)*



Scale 60 feet to 1 Inch

these Sluices were from the bed of the River 6 feet in height, and above this point the floods passed over the Dam in one unbroken sheet of water

At the time that this work was constructed, in 1828/29, the bed of the River at the point where the Dam was built and both above and below it, was one uniform slope, with a section of 8 or 9 feet in depth from the Surface of the Country, see Diag: V. Fig: 4.-

From the rains of 1830 to those of 1834, a constant succession of retrogression of level upon the Masonry tail of this work took place; in the rains of the latter year a portion of the tail apron fell, and a new tail was constructed partly of masonry and partly of Timber and boulders, flanked by Bundles and fascines; this new tail was made on a slope adapted to the depressed level that the bed of the River had at that time assumed at and South of the tail of the Dam. —

At the commencement of the rains of 1841, that is to say. Eleven years after the Dam was constructed, the total width of the tail apron, which had annually been receiving an accession of Material, was 80 feet on its transverse section; Year after year extensions had been made, and as it was hoped, addition had been given to its stability. Early in the rains of 1841 however, a very heavy flood came down the Nogong River; the water in its passage over this fearful rapid

of

of box work (the bed of the River South of the tail being at this time 21 (twenty one) feet below the Sill of the Dam) turned the piling and hurdle work on the left flank carried away that portion of the tail in its immediate proximity and was only checked in its career of destruction by the Masonry platform, over which it fell in an uninterrupted cascade of at least 15 feet in perpendicular height. The injury was of such magnitude, and the accident had occurred at a period, when a succession of floods during the three following months were certain, that there was neither time nor material available for doing anything further than making a moderate repair, and the only prospect that offered of preventing irreparable injury was by passing off flood water down the Canal Channel; and if possible putting the Dam out of use for the rest of the season. It so happened that during the rest of the rainy season of 1841, the floods that came down the River were passed down the Canal Channel with the greatest ease, and in so far our arrangements were crowned with the most perfect success.

By a concurrence of unforeseen failures in the manufacture of materials, and chiefly in the deprivation of European superintendence arising from sickness, the new works which

during

during the following cold weather had been in progress for the pro-
-tection of the tail, were only im-
-perfectly finished when the rains of 1852 set in: these rains com-
-menced with unusual violence and on the 23rd of June, a heavy and continued fall of rain confined it appeared to the upper part of the Doab, led to the whole of the Rivers connected with the Jumna being flooded to an enormous extent: the coffer dams built for the protection of the Sluices at the Nogong works, were either not, or only partially removed the floods swept over the works which were imperfectly indurated and carried away the whole of the Central portion of the Dam, leaving the Side Revetments standing, with a gap between them of 150 feet in width, vide Ding: V fig 2. This removal of an obstruction to the course of the Current, led to an entire revolution in the bed of the River. the abrupt slope which I have before described as formed at the tail of the Dam by a succession of retrogression of levels was entirely obliterated; the bed of the River after the flood had ceased, had assumed One uniform slope, and there was a deposit over a portion of the Masonry tail (that has from the looseness of its position not been affected by the action of the floodwater) of no less than 12 feet in depth, of sand. A careful inspection of the plans and sections of the Nogong River with the dif-
-ferent levels that the bed occupied

1st

1st at the period when the works were constructed; 2nd & 3 at a period antecedent to the occurrence of the accident when the retrogression of the levels on the tail had arrived at their maximum; 3rdly The state of the bed after the accident; vide Diag V, fig: 3, will be suggestive of interesting reflections on the nature and circumstances under which our canal works are placed in connection with these mountain torrents.

In comparing the effects at the Ramjoor with those at the Nogong works; we see in the first case, an open and capacious inlet with its Sill placed 2:72 feet below the natural bed of the River, or at such a depth that the action of the current passing over the surface in its natural state would not in any way have interfered with it; in other words, that the Regimen of slope and soil would not by the intervention of the Inlet have been interrupted: we see the Torrent pouring its waters over this Inlet upon a lower line of levels, artificially excavated as an escape the slope of which was reduced far below that which Nature had designed for it. In the case of the Nogong Dam, the Sill of which was on the natural surface of the bed of the River, and consequently destructive to the regimen of the flow of current over a sandy bed; we see a Torrent pouring its waters over an escape upon a depressed line of levels, as much opposed to its natural distribution, as that on the artificially excavated

excavated outlet for the Ranipoor River; we see the obstruction of this Dam on the Nogong River violently removed, and no sooner does nature assert her own influence than she at once returns to her uniformity of Slope, ~~and~~ There can be no reason for doubting that although our experience of the effects of this accident at the Nogong Dam, only pointed to those of one rainy season; a succession of floods would by a succession of deposits have restored the bed to its original levels as shewn by the upper line in the section, precisely in the same way in fact as the succession of floods at the Ranipoor Ras acted in the restoration of the levels to their natural uniformity.—

The question might, perhaps, have been one of degree in so far that the proximity of the Ranipoor works to the mountains and the excess of slope upon which the Torrent runs at the point of intersection with the Canal, would have effected in one season, that which under ~~the~~ peculiar circumstances both in distance from the Hills, and reduced slope of the Torrent might not in the case of the Nogong Excavations have been effected in many years. In both these cases the natural effects arising from Artificial causes appears to me to be very much the same.—

The consequences of building masonry

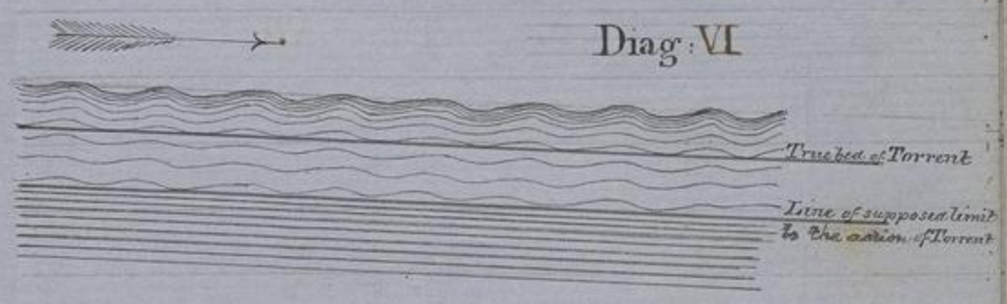
Masonry Dams and platforms across the beds of Mountain Torrents running under circumstances like those of the Muskuna and Nogong Rivers had in both cases proved that a retrogression of levels ~~and~~ with an attendant deepening of the bed of the River upon their lower side ~~was~~ were inevitable.- Both these Rivers run in well defined sections, and their beds were con-=siderably below the surface of the country; the slopes upon which the beds were maintained (in the case of the Muskuna 9½ feet per Mile, and in that of the Nogong 11½ feet per Mile) were clearly dependant on a natural regimen which admitted of an equability of deposit of moving masses of Sand. The effects of destroying this regimen by placing a bar of Masonry, or a bar of any material whose substance was more rigid and of a denser nature than the material that formed the bed of the River itself, might naturally be expected to result in a dis-=arrangement to the uniformity of deposits below the bar, and in ~~such case, giving to the current~~ a power of wear and tear upon the bed given to the current at that particular point which without any coun-=teracting medium the extreme slope of surface rendered un-=avoidable.-

To explain my views on the above question, let us refer to the following diagrams shew-=ing a portion of the course of a Mountain Torrent flowing

over

over a Sandy bed

Diag: VI.



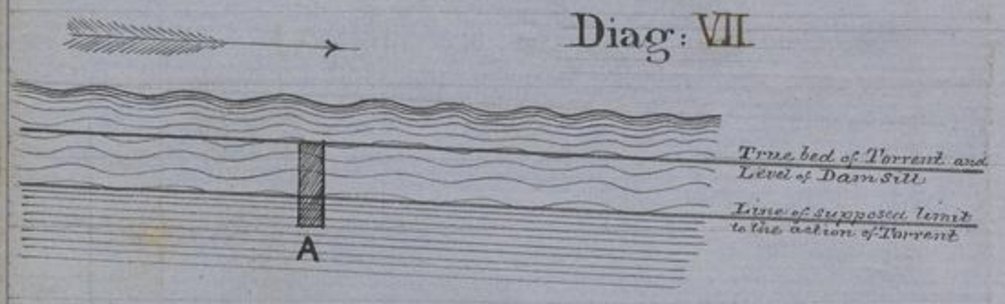
From the above diagram it will be understood that during the action of a Torrent, the upper surface of the bed is under a forward movement, that the whole mass of sand of which the supersoil of the bed is composed is dislocated and torn up by the violence of the current; and that during floods, the Sand and water are carried forward in a headlong course to the lower levels, where the former is either deposited by lateral inundations or by meeting with levels running on a diminished slope; or, as is frequently the case with the Torrents in the North west, by its joining the great Rivers, in the advancing volume of which its sands are engulphed. The above is a representation of the Torrent in its natural state, and its action upon the Sandy bed as above shewn is, I believe, undisputed.

Repeating the above diagram and introducing the disturbing element caused by a bar of Masonry, or by the Nogong and Muskuna Dams, the position of which is effectively shewn in the diagram, we appear to arrive at the following con-

clusion:

= Sessions.

Diag: VII



1st That the interposition of the bar **A** must necessarily act as a disturbing element in the uniform advancement of the sand; and that at this par=ticular point during the pe=riods when floods are running, the tendency of the current in its full depth to rise over the bar **A** leads to an increased velocity on its downstream side which must more or less influence the action of the current on the bed, and that this ~~disarranging element of increased velocity~~, small as it may be, but connected as it is with the ~~disarrangement caused~~ obstacle presented by the bar, to the uni=form progress of the sand, places the bed of the River on the down stream side of the bar, under an entirely different regimen to that which exists on the upstream side, and that this difference of regimen is in favor of a wear and tear upon the bed of the River below the bar.-

2nd That in the case of the Dams on the Muskinna and Nogong Rivers, during the 8½ or 9 months when the beds

beds of the Torrents are dry, the leakage through the Dams, and the discharges of Escape water, can only act in carrying matter forward, and the Slopes upon which this advancement is effected, are on such an exaggerated scale, that the wear of bed and consequent retrogression of levels are inevitable.—

Another and a third representation of the above diagram is illustrative of the effects upon the bed of a Torrent when the Sill of a Dam or bar of Masonry is placed even with or below the line marked as that of "the "Supposed limit to the action of "Torrent," and its introduction here as illustrative of ~~another~~ matter that will hereafter follow, is convenient.—

Diag: VIII.

The Sill of the Dam B is here supposed to be below the fluid matter in motion, and beyond the influence of the action of the current; its existence, therefore, is harmless as far as disarranging causes are concerned, and as it in no way affects the natural habits of the River; its admission under any form or shape is legitimately safe; and this safety increases with the depression of the Sill below "the line of supposed limit to the action of Torrent"

The

The extraordinary accumula=tions of sand which were attend=ant on the floods of the Ranipoor and Puttri Torents with which we had to deal on the Ganges Canal works; and the ~~superficial~~ action which they appeared to exert on the Surface of the country, opened out new considerations as to the Method of dealing with them. The alignement of the Ganges Canal came in contact with these Tor=rents at points high up in their courses and in regions where in escaping from confined Channels they poured over the surface of the Country Sheets of Sand. Across these extensive ~~Sheets of Sand~~ areas, the line of canal had to pass under the difficulties of its bed levels being in one case 12·725, and in the other 9·57 feet below the surface. The circumstances under which the Rumna Canals came in con=tact with their Torents were in no way coincident. The line of the Ganges Canal on its course between the Ranipoor and Rutmoo Torents was literally (unless some other means than those originally devised, were projected) a Catch drain of very imperfect dimen=sions for the silt brought down from the mountains by the periodical floods.

It was evident in fact from the experience that we had gained by observing the Ranipoor works during the floods of 1849, that the quantity of Sand ~~that would be~~ annually brought into the Canal Channel under the projected plan of works

would

would be enormous, and that an influx of silt equal in extent to that of 1849, if to be annually expected in each of the two Torrents, viz: referred to the Ramipoor and Puttoo, would not only lead to the greatest expense and annoyance hereafter, but that in the working of the Canal the evil would be unbounded.—

The only efficient remedy that suggested itself for overcoming the difficulties arising from these silt bearing Torrents, was one which from the enormous expense that would attend upon its adoption, and from the time and labor that would be required to complete it, was naturally open antagonistic to reasonable objection commendation: it implied excavation a cutting out from the low levels in the Rutmoo valley back to the Puttri, through the heart of the Springs (which I have before described as existing in the Badshahpoor Nulla) and on a distance of no less than 3 Miles. It implied a similar operation, under more favorable circumstances with regard to Springs on a line upwards of a Mile to the Ramipoor valley, and it necessitated a total and complete re-distribution of the Masonry works, and what was of equally material consequence, it implied also a complete re-arrangement of the drainage.

The plan of passing the Ramipoor and Puttri Torrents over the Canal ~~which appeared to be the only remedy~~, might be compared to a design for disposing of the Nogong

namely, passing the floods, over instead of through the Canal channel

Note. to be given to the Printer when called for.

Nogong and Muskuna Rivers over the Eastern Dumna Canal by a similar process, in which the low levels of the Belka falls in one case, and the low levels of the Bobyl and Nugla falls in the other, would be carried back to points in the Canal channel above those of its intersection with the courses of the Torents.—

Before any determinate measures could be recommended so seriously affecting the amount of the original Estimate, as the remedy, to which I have just alluded, would lead to, it was necessary to examine with a mind as unprejudiced as possible the existing causes and effects of the sand deposits, bringing to this examination our experience on the Dumna Canals; combined with that which we had so lately gained in the case of the Ramjoor Rao ~~as it affected the Ganges canal works~~, thus deciding: and the general question as to the method that could be best adopted for meeting the difficulties of the Ganges Canal works ~~Latter~~ in their existing state of progress.—

The question was thus brought within defined limits, and it appeared to me, to resolve itself into the following argument.—

The natural law by which the Phenomena alluded to were guided, was to be explained on the principle which was well known as operating on artificial lines of canal both in these Pro=vinces and elsewhere, where the early

early part of the courses of the Channel runs on extreme slopes through deep sections excavated through a light sandy soil, and on beds inadequate to withstand the attrition of the current. The Phenomena here alluded to, have been too practically exhibited on the Eastern Jumna Canal to require any further consideration; they are in fact an exhibition of that law in nature, which makes running water regulate its own course and its own declivity: this in running Rivers being most apparent in tortuosity of direction; in artificial lines (where tortuosity is prevented by Embankments) in an adaptation of the bed or declivity of Channel ~~to meet~~ by deposits of silt to the regimen due to velocity of current. -

The Eastern Jumna Canal affords a good exhibition of the law in artificial lines. -

The upper or northern portion of this Canal was excavated on an excessively steep slope, in a light and sandy soil; the lower or Southerly portion on irregular and moderate slopes, and through good firm soil. The results of this distribution of slope were after a very limited period shewn in a manner represented by the following Diagram, where the black line shews the original bed upon which the Canal Channel was excavated, and the dotted red line the slope which the current adapted itself to

to

Diag: IX.

The process by which the new slope was arrived at is thus ex-=plained - The velocity of the Cur-=rent led to an abrasion of the bed at BC as represented by the shaded portion of the diagram The soil thus abraded was carried forward until by a decrease of the velocity of the Current, arising either from diminution of slope or from decrease ~~of~~ volume, the water was no longer able to re-=tain the matter in suspension and at the point x the ~~original~~ first deposit established itself: in the rear of ~~x, or in the rear of~~ this deposit, a stillness of water, added to the causes before mentioned, led to further deposits, and by a gradual, but very evident process the whole space XCBx was filled by deposits retrograding from X to B as shewn by the black dotted lines. -

A further retrogression of the wear and tear at A in the canal bed, led to a deposition again in advance of the point X with an after process corresponding in every respect with that before explained: this continued until the retrogression at A was put a stop to by the intervention of masonry works built for the purpose. For the particular object of the present argument, there is

no

no necessity to carry the explana-
=tion further, but it is sufficient
=ly illustrative of the effect of
silt loaded waters, running on
irregular slopes in an artificial
and embanked Channel.-

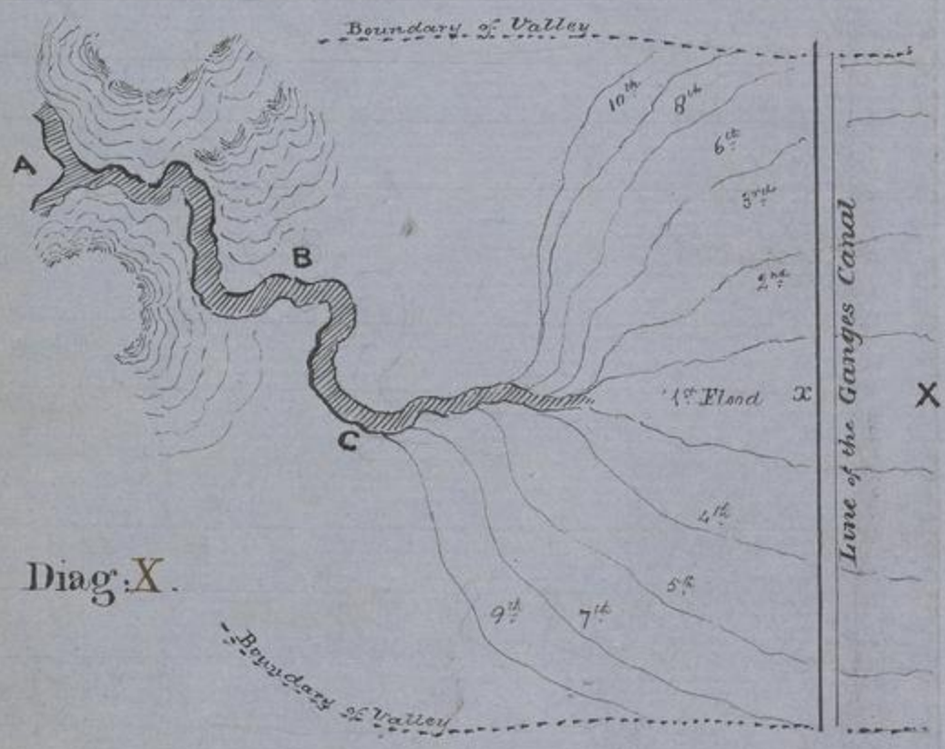
We will now consider a case
where the Channel has no Embank
=ments, and where the water per-
=petually loaded with silt flows
over the surface of the Country.-

It is clear that the precise
point x at which the deposition
commences, is necessarily deter-
=mined by the power of the water
to carry silt forward; in an Em-
=banked Channel this power will
act to a considerable extent and on
long lines, checked only by a decrease
of volume (arising in Irrigation
Canals from expenditure on water
course heads) or by decrease of the
slope. In lines not Embanked the
water from spreading over the
country is immediately subjected
to a reduction of velocity, and con-
=sequently ~~the~~ an immediate in-
=clination to get rid of all heavy
matter by deposition: the point
x will, therefore, in this case be
situated closer to the field of abrasion;
at any rate it will exist at some
point
or other in the course of the River;
and as I have before shewn, at
that point where the velocity
of current is inadequate to
hold matter in suspension.-

Whether, therefore, the Channel
is embanked or not, the same
laws operate in both cases. the
same ends are obtained by a pro-
=cess similar in every respect,
although

although under different circum-
-stances

In the following Diagram, using the same letters as before, is represented in plan or map, the surface of a country where the Channel has no embankments and where the water perpetually loaded with Silt flows over it



Diag: X.

AC having a steep slope, and CX a comparatively moderate one

The line of River from C to X would run on a tortuous course spreading and throwing up to the right and left slight deposits as may be observed in the region of all alluvial Rivers* on its gain-ing the surface of the country where unshackled by any Channel or

sections

* Where a Silt bearing River separates into Two branches, either at different Angles to the main stream, or on different slopes, that branch having the least slope or at the greatest angle will have a tendency to Silt up. It is thus with the Outlets and escapes from our Canals, which being on a less slope than that of the main line, and in most instances being at right angles to it, have always a tendency to deposit at their mouths, so also at cattle Ghats, and at still places on the right or left of the Stream.

To see this in a practical point of view look at the Rajbuhas, or main lines of Flood courses on the Jumna Canals, and the princi-pal clearances of Silt which they require; the deposits in these Rajbuhas never extend more than 1 or 3/4 of a mile from the main Stream; from a rapid deposit of course Sand

at

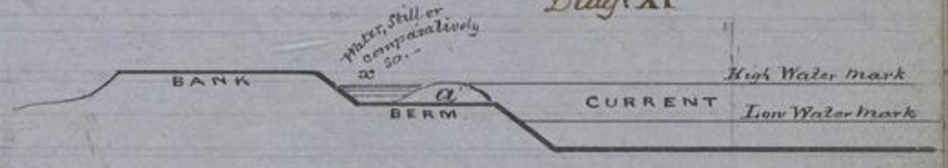
Section the water by spreading would lose all power of holding matter in suspension, the deposits would take the form as represented at

---

at the point of departure, they dwindle off to that of the finest mud; the whole progress of a deposit may be observed, studied and understood, by any person who will from the Rajbaha Head walk down its course.

In Silt bearing Rivers, the waters of which during floods spread over the country to the right and left, the water on leaving the main Current, immediately has a tendency to deposit the matter suspended in it, the disposition of the deposit depending upon the gravity of the matter in suspension; this deposit is exhibited in a talus sloping outwards and away from the River: any person travelling along the Jumna Canals, where the height of the surface water is very variable, and where the water is loaded with silt, will observe the deposit on the berms, and may even see the action in progress: thus:-

Diag: XI

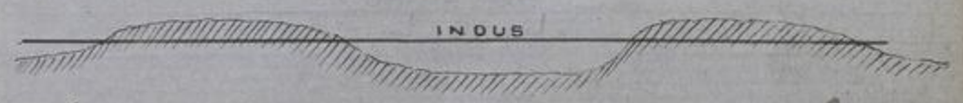


a' being the silt deposit, and x either a trifling Stream or Standing water.-

The same is apparent in the Khadir lands of our mountain Torrents only on a larger scale: the hollow x being invariably exhibited in either Nullas or Marsh at the foot of the high land skirting the valley: the same is seen in the high steppes of the Ganges and Jumna (which although now far removed from the action of the River which has excavated for itself a course on a lower level) where a Nulla or Marsh invariably exists as the representation of x: this is clearly seen in the Gosainwala marsh, and in others in that neighborhood in the Eastern Doon, as well as in the lower flats at Bhogpur, and similarly situated land on the Jumna.

On the Indus the most magnificent exemplification is shewn of the same law where for a mile on each side of the Rivers course the land is elevated, whereas the surface of the distant Country is below that of the water of the River.- The following Section of the Indus, for which I am indebted to my friend Major W.E. Baker of the Bengal Engineers, is literally that of an artificial Canal with embankments, the latter being composed of Silt deposited during inundations

Diag: XII.



The fan like and convexical form which ac-

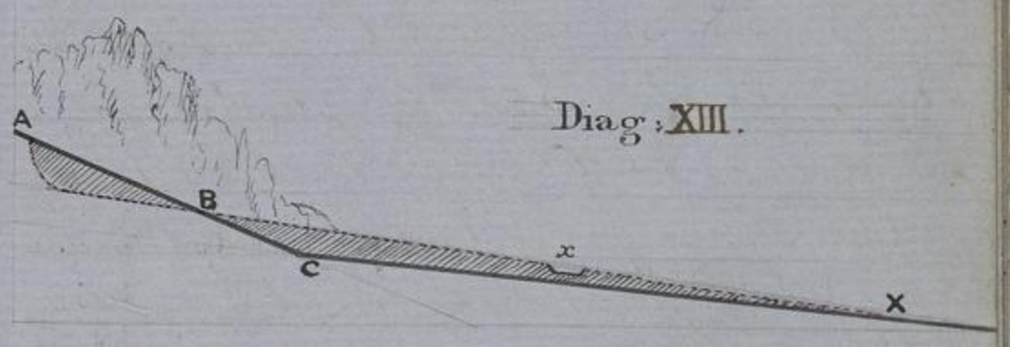
at X, terminating in a fan shaped
field of Silt, which would assume
a convex form (as may invariably
be observed in deposits of this sort)
and would exhibit the remarkable
appearance which is so recog=
=nizable in the Ramipoor and
Puttri Torents, where the bed of the
River after the Rains, is on a high
=er level than that of the neigh=
=boring country. —

I have by black dots shewn
the limits of the basin in which
the floods are supposed to act; the
tendency of such action being
undoubtedly to raise the surface
of the Valley; the course of the
preceding year could not from
its elevated position be that of
the next; this next flood would
throw out another fan of sand
laterally situated to that of the
preceding year, and so on an=
=nually as figured in the diagram,
until a deposit similar to that
at X would be distributed over
the whole surface of the Valley;
this would it may naturally
be supposed lead to the same
action as was before described as
occurring on the artificial line
of

-posits assume, when Silt bearing water
running on a steep declivity, escapes from
its Channel and spreads over the surface of
the Country, is too conspicuously shewn
at points on the Eastern Jumna Canal, where
fractures have taken place in Embankments
much elevated above the surface of the Country
to have escaped the attention of men in the
Canal Department; but the rationale is
too clear to require further explanation,
when the effects of deposit, depending
on the velocity of the Current and the
gravity of the suspended matter
are taken into consideration. —

of Channel, with consequences pre-
-cisely the same, and to use the
words of a former paragraph,
by a gradual and very evident
process, the whole space XCBx
would be filled by deposits retro-
-grading from x to B as shewn by
the dotted lines in Diagram IX..

Now, let us consider that in
the case of the Ranipoor and Puttri
Torrents (which strictly deserve that
name, from their being perfectly
dry excepting during floods)
and the deposits of sand which
occur at that part of their course
where the Canal comes in contact
with them; the letters A B C of diagram
XIII, represent the Sewalik Hills
with their steep slopes having a
perpetual tendency to degradation
from the quantities of shingle and
sand which are carried out of
them during every flood; and that
B X is the tract at their foot through
which the Ganges Canal takes its
course as represented by the dou-
-ble line. Now repeating the
diagram as a representation of
a longitudinal section through
the Map in Diagram X, we
have the Ganges Canal at the point
x excavated



Diag: XIII.

in the deposit, and actually in
the position of a Catch drain for
the reception of all the detritus
brought down from the Hills A B.

It

It is a point, moreover, most especially worthy of attention, that the very fact of the above Two Rivers being Torrents, and not Perennial streams is greatly in favor of deposits at their immediate debouche from the Mountains: the floods are in fact Spasmodic disgorgements of heavily silt laden water, Spreading over the Surface of the Country, and frequently losing themselves by absorption and other causes before they reach the Rivers to which they are properly tributary.—

Under the above view of the Question it appeared to be impossible that any works constructed on the principle of passing flood water through the Canal could (situated as I have described the works to be both in position and level) be free from ~~the objections of being liable to~~ very extensive deposits of sand; nor would it have been practicable to maintain the Escapes from the Canal and in the direction x x as open and efficient Channels, without Annual and most extensive clearances.—

Having arrived at these conclusions, and being justified by the results of the floods of 1845 on the Ranipoor works, I considered that the following facts were established

1st That the Canal Channel under the project of 1845, would be subjected to greater deposits of Sand than were before anticipated

ticipated.-

2ndly That consequently the annual outlay for getting rid of the inconvenience would be very heavy.-

3rdly That the whole State of the Questin gave me legitimate grounds for incurring increased outlay where the object to be attained was one of such immense importance in ultimate economy

It may be hardly necessary to observe that in illustrating the above argument, both the Diagrams themselves and the descriptions as far as time is concerned, are exaggerated in every sense: that the time occupied & when nature is not interfered with in gaining the results to which I have drawn attention runs & through an infinity of ages; that thousands upon thousands of years have been expended in gaining the Configuration of the Earths surface as it now exists in the region upon which the Canal takes its course; that the proces is so slow that human life and human intellect are incapable of appreciating it; but degradation of matter is certain; the Sewalik Hills which are now such an ornamental feature of our world, will in the course of time dwindle to nothing, their substance has been for ages, and will be for another succession of ages, undergoing dispersion over the Earths surface; the land at the foot of the Sewalik Hills is

Year

gaining in elevation
Year after year ~~rising on surface~~
as the Hills themselves fall to pieces.
and although the immeasurable
Periods at which great changes
take place are not matters to be
considered in human undertakings,
a steadily proceeding cause like
that alluded to above, in which
there is a perpetual tendency
to deposit, assured me of the Cor-
-rectness of the results at which
I had arrived in maintaining
the Course of the Canal and
that of the Hill Torrents distinctly
separate.

In recommending therefore,
that the Course of the Ranipoor
and Puttri Torrents should be
carried over that of the Ganges Canal
I observed, that if the Phenomena
attendant on the regimen of the
Slopes of the Mountain Torrents
at that particular point of their
Course where they came in Con
-tact with the Canal works, were
as I had stated, it was evident
1st That it would be an evil
of the First magnitude to
let these Torrents with their
Silt enter the Canal Channel
2nds That if a Superwaterway
for the passage of the Torrent
is made of sufficient width,
there will be no tendency
to wear and tear on the
bottom passing from the Masonry
Superpassage to the Soil of
the Surface of the Country*

3rds

*It was not meant by the expressions above used, that there would be no tendency to excavation at the immediate tail of the work; but that this excavation would be a mere local evil, subject to being filled in more or less on the subsidence of floods, and not one affecting the downward levels of the Escapes.

3dly That as there is no tendency at this particular point to a retrogression of levels, the Torrent may be carried over the Canal with perfect security.—

The advantages of passing the floods over the Canal, were in every respect undeniable; they resolved themselves into the following

1st Utter freedom to the Canal Channel from Silt, and the evils arising from the contact of two Streams meeting each other at right angles.—

2nd Freedom from all the wear and tear of Channel necessary on the admission of the Torrent into the Canal bed.—

3rd Freedom from the anxiety of opening and shutting the Sluices, and regulating the escape at the Dams.—

4th Freedom from all Establishment for working the Dams, and a consequent reduction of a large permanent Establishment necessary for their maintenance.—

On the other side was the enormous additional expense; which it was hoped would in a great measure be neutralized by the ultimate saving on Establishment, Silt clearances, and General repairs.—

In my letter of the 12th of April 1850, the arrangements depending on the improved project were thus stated

"Superpassages therefore, for the Torrents while

"will be constructed on the main
"Channel at the Ramipoor and
"at the Puttri Raos. In the first
"case the 1st Fall at Bahadoorabad
"will be moved back to a distance
"of 5748 feet (One Mile and 468
"feet): in the second case the
"Dhunowri falls which in the
"original project are situated on
"the left bank of the Rutmoo
"River will be moved back to a
"distance of 15630 feet (3 miles
"nearly): in other words.

"1st The 1st Bahadoorabad Falls
"and Locks and the Ramipoor
"Inlet and outlet of the original
"project will become one work
"2nd The Dhunowri Falls and
"Locks and the Puttri Inlet
"and outlet will be united"

The general design of the works arising from this change of disposition of Slopes and method of dealing with the cross drainage will be very clearly understood by a reference to the accompanying outline, which shews the details of the works from the Jowallapoor Bridge to the Rutmoo Torrent, both on the project of 1845, and on that which has just been explained of 1850, vide Diag: XIV.

With these outlines, as well as with the Transverse sections (vide Diag: XV) explanatory of the different methods of passing the Torrents over the Canal Channel before him, the reader will without difficulty be able to comprehend the precise nature of the change that has been effected, and the position of the different works as they have been actually executed.—

With

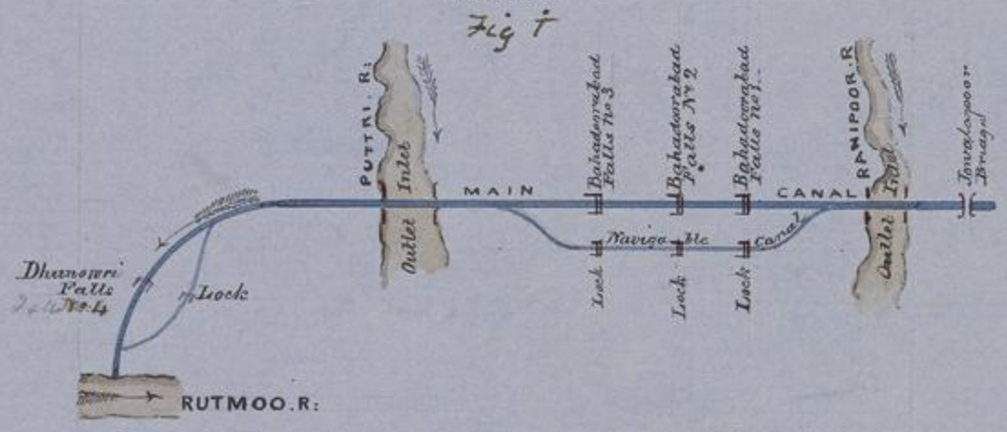
Diag: XIV.

PLAN OF THE GANGES CANAL

From the Ranipoor to the Rutmoo River

Shewing the position of the Works as originally projected in 1845.

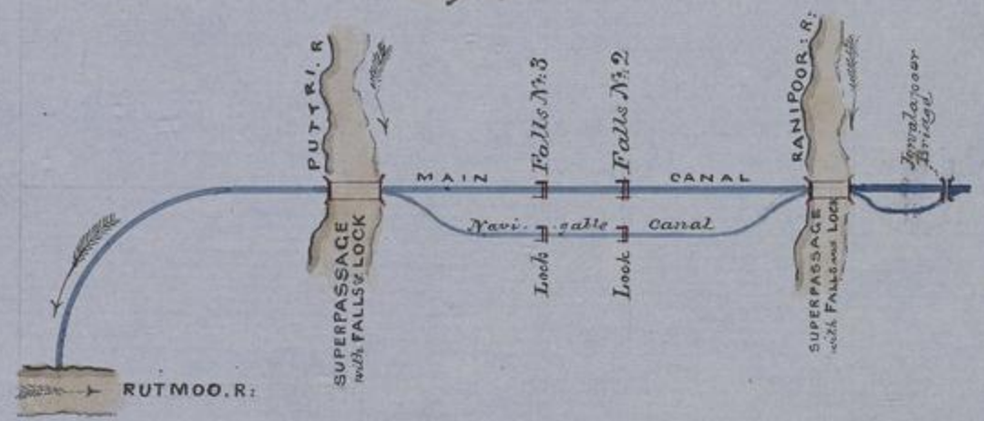
Fig I



PLAN, *as above*

Shewing the Position of the Works as projected in 1850

Fig II



On no Scale

Diag: XV.

Transverse Sections of the Ganges Canal, at the point where the Ranipoor (torrent) River crosses it

☞ The blue dotted lines represent the direction of the Stream in the Ranipoor River under the different plans proposed ..

Fig: 1.

Agreeably to Project of 1845

Fig: 2.

Agreeably to Modification of 1849

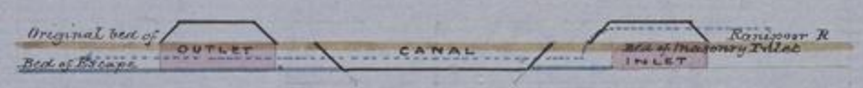
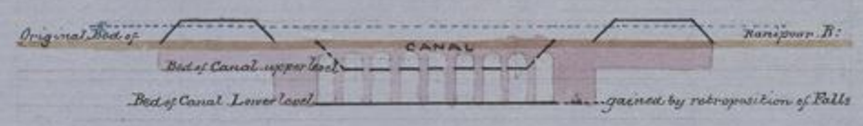


Fig: 3.

Agreeably to Project of 1850



On no Scale

With regard to slope, the bed of the Canal on the Sill of the Falls No 1 at Ranipoor was main=tained on its original level; the falls which were nine feet in perpendicular descent although constructed in the form of an ogee, delivered the water on a Channel 143 feet wide with a slope of bed equal to 1·052' feet per mile, and extending on a line of 9742 feet to the Sill of the No 2 Bahadoorabad Falls; a descent of 9 feet at this point, delivered the water on a Channel 170 feet wide with a slope of bed equal to 1·3' per mile, and extending on a line of 2695 feet to the Sill of the No 3 Bahadoorabad Falls; a descent again at this point of 9 feet delivered the water on a Channel of 160 feet wide with a slope of bed equal to 1·2' per mile and extending on a line of 11963 feet to the Sill of the No 4 Puttri Falls; from this point where the last Masonry descent occurs the water is delivered on a slope of 1·21 feet per mile, which terminates on the flooring of the Dhunowri Bridge. —

It will be observed, therefore, that the uniform slope of 18 Inches which was designed in the project of 1815, was very con=siderably reduced, the reduction having been gained by giving an additional 12 Inches to each of the Masonry descents. To meet this reduction of slope however, additional width was given to the Channel, from the Tail of the Ranipoor to the Head of the

Puttri

Puttri works; South of which the interuptions which were met with from Springs, led to a modification of the dimensions which were elsewhere put into practice

The direction of the Canal was in many respects similar to that of the original project. Both at the tail of the Raniproor and at that of the No 3 Bahadoorabad Falls however, there was a change of direction of $5\frac{2}{3}$ degrees to the right. ~~With the exception of these changes~~ after which the Canal was carried on a direct bearing ~~to the Rutmoo River or~~ to the village lands of Dhunowri, ~~on which it made a turn of 62½ degrees to the left across the Rutmoo~~ Torrent, and ~~straight upon the Solani Aqueduct~~ — At this point the gentle curve upon which the line of Canal in the Project of 1845 was brought down upon the Rutmoo River, was for reasons to be explained hereafter, rejected; the more abrupt turn with sides well protected by Masonry Revetments being preferred ~~to that of the original project~~.—

Here a curve on an angle of 62½° tangential to the line of channel in its approach to Dhunowri, and to a direct line bearing upon Rookee delivered the Canal on the Rutmoo River

The soil through which the excavation was to be carried, was of a light description, but by no means unmixed with clay; Shingle in small quantities was met with here and there, and as far as the head of the Puttri Falls, no Spring water interfered with the excavation The retrosposition of the 1st Set of Falls led to excess of diggings of 9 feet in depth on a length of 574 8 feet, with its attendant

increase

increase to the dimensions of slopes. From the head of the Puttri Falls however, to the Putmoo River, on which by the proposed plan, an excess of depth of 13 feet on a length of 15630 feet was to be excavated, the difficulties arising from Spring water were very great; the detail of these difficulties will be found in its proper place when the Canal Excavation is brought under general review.

The passage of the Ramipoor Torent over the Canal ~~is to be arranged~~ obtained by throwing arches over the lower levels of the Falls, the water way of which was divided into eight parallel descents of 25 feet in width, with a passage of 19 feet in width on the left for the navi-gable Channel. The Inlet and Dam which had been already built were imbeaded in the side walls or abutments of this new building, so that ~~with regard to~~ the ~~masses of~~ Masonry of the old works, ~~was disposed of in~~ ~~this uses were converted into~~ the most economical ~~purposes~~ way. The superpassage which rested on the arches ~~which were~~ thrown over the bays of the Falls, has a clear water way of 200 feet in width with all the necessary appliances for its protection on the ingress and egress of the Torent.

The Bahadoorabad Falls No 2 and No 3, which are situ-ated immediately below the Ramipoor works, ~~are these~~ provided with a waterway of 200 feet each in 8 Bays of 25 feet each. Below the

the No 3 Falls and on the right of the Canal, the Selimpoor Inlet (which is constructed exactly on the same design as that ~~which have been before described as~~ built at Dowlapoor ~~No 2~~,) admits into the Canal Channel the drainage which I have before described as unconnected with the Hills and subordinate to that of the Puttri; the width of waterway of the Selimpoor Inlet is 150 feet. —

The Puttri Superpassage which is 300 feet in clear width of Channel, is arranged with reference to the Falls and Navi-gable Channel precisely in the same way as that before described at the Ramipoor works: all the necessary appliances for its protection from the ingress and egress of floods, have been carefully adopted. —

On the right of the canal at a point 10804 feet below the Puttri works, an Inlet with a water way of 50 feet in width, has been constructed for the pur-pose of admitting the stream and floods of the Badshahpoor Nulla; the design of this work is similar to that which has been universally adopted for Inlet purposes. —

The Rutmoo Dam ~~and works connected with it, consist of~~ approaches by well protected Masonry Revetments for the purpose of securing a safe change of direction to the course of the Canal on its approach

to

to the River. The River is crossed by both Inlet and Outlet, and is cut off from the works on the Peeran Kulleeur ridge by a Regulating bridge constructed on the same scale and fitted with the same apparatus as that at the Canal head at Myapoor. — This Bridge gives the means of cross communication over the Canal on the right bank of the Rutmoo River, whilst a plain Bridge which has been built across the Revetted portion of the Canal Channel on its approach to the Rutmoo, gives the means of cross communication on the left. — The Dam is fitted with Sluices which give a waterway of 600 feet; over the Pier heads which are 10 feet above the bed of the Canal, the works afford a flush Escape for Flood water equal to 800 feet in length.

The distribution of Escape from and Inlet to, the Canal Channel from the Myapoor Regulator, to the Rutmoo Dam, as designed in the Estimate of 1845 and compared with those which have been adopted on the Explanations of 1850 may be thus described. —

	1845		1850	
	Inlet	Outlet	Inlet	Outlet
Lounda Leniwala	20	20	50	—
Kunkul	10	—	50	20
Dowlaproor	—	—	100	—
Raniproor — (Inlet free) say	131½	131½	—	—
Selimproor — (— do —) —	23½	23½	150	—
Puttri — (— do —) —	131½	131½	—	—
Gurh — (— do —) —	23½	23½		
Badshahproor	from	from	50	—
Rutmoo — (— do —) —	796½	796½	800	800
Totals	1136½	1126½	1200	820

In

In other words in the early project the whole of the drainage to the right was ~~proposed~~ to be passed off by escapes equal in width to 1126½ feet, whereas in that of the later date, the whole of this drainage minus 500 feet in width, ~~was proposed to be~~ passed off through 820 feet of opening. The new project does, in fact, therefore, give an escape of 820 + 500 = 1320 feet or 193½ feet more than that originally contemplated.

It is questionable whether the Amount of drainage which on the project of 1815, was admitted into the Canal by apertures left in the Embankments would not have affected the Canal supply passing down upon the Rutnoo Dam, to an equal, if not greater extent, than the numerous in-lets which have been latterly designed; the admission however of so much water without any apparent escape for it, as is given at the Loondu Leni, & Dowalapoor, Selimpoor, and the smaller Inlets, is a more palpable evil; it is nevertheless more so in appearance than in reality, the breadth of Inlet by which in the foregoing table the amount of volume has been estimated, having been ~~in the~~ given to facilitate the ingress of floods over an expanded surface, and thereby to relieve the Canal Chan-nel as much as possible from the Effects of a confined and con-tracted waterway —

with

With a view however to meet the Contingency of an overloaded Canal Channel, the Embankments on the left and immediately opposite the Inlet at Celimpoor have been omitted, so that on any extraordinary rise of high water, the flood may pass over; the effect is an awkward one, as in so doing the navigable Channel which runs parallel, although at some distance from the Canal on the left, would be swamped; the cost however, of the restoration of this line of Channel would be trifling to the damage that might otherwise be inflicted on the main line of works, and after all the contingency of floods of this sort occuring is one that (Diag 2 & 3) ~~so to be expected~~ ~~Anticipated~~, altho' it is better to be prepared than otherwise

The Navigable Canal Channel which in the Original Project (vide the Sketch which has been given in a former page (Diag XIV. Fig 1) left the main Canal at a distance of 4000 feet from the head of the Falls, and re-entered ~~the Channel~~ it at a point below them, has in consequence of the rejection of the drainage works, been considerably modified, and very greatly improved.—

The Head of this Channel now (Diag XIV Fig II) leaves the Canal on the left bank immediately above the Dowlapoor Bridge, of which

which the works form a compo-
-nent part; by placing the head
in this situation, we hold the
means in our power of prevent-
-ing rafts and craft of any
description that may pass down
the ~~Canal~~ Canal from coming in contact
with the descents, or cataracts
as they may be called, by which
our superfluous slope has
been disposed of, and we thereby
give an increased security to
the navigation, ~~which is in every~~
~~way desirable~~.—

After leaving the Towal Poor
Bridge the line runs parallel
to the Canal, and reaches by a
Masonry Channel, brought down
~~upon the back~~ by a gentle curve
a lock with a Drop of 9 feet situ
-ated on the left and forming
the left bay of the Ramipoor
Superpassage*. After passing
the Lock, the Masonry Channel
goes off in another gentle curve,
and delivers the water on an
excavated

* At the Head of the Lock Chamber at the Ramipoor Superpassage, the Masonry Channel is divided into two; that One on the right which is 16 feet in width giving the Drop for Lock purposes; the other, or that which is situated on the left, which is 10 feet in width continuing on the upper levels under the superpassage, for the purpose of supplying Mills for grinding Corn at Bahadoorabad: the intersection by this Channel of the curve of the Navi-gable line which is situated directly below the superpassage, a crossing is effected by an Aqueduct, from whence it proceeds to a cluster of Mills, which are constructed on the site of the No 1 Locks of the project of 1815. By taking advantage of the means at my disposal for establish-ing a Channel for the water under the superpassage of the Ramipoor Torrent, I was able to get efficient head supply for the Mills which could not well have been obtained otherwise.—

excavated Channel running paral=lel to and at a distance of 900 feet from the line of the main Canal. on this ~~straight~~ portion of its course the line the descent of Country which is passed in the main Canal by No 2 and No 3 Falls, is overcome by Locks of 9 feet drop each: the Navigable Channel on its approach to the Falls and Supr passage of the Puttri Torent, enters a Masonry Channel, which meets the Supr=passage and passes the descent in the same way as I have de=scribed at the Ranipoor works. ~~At~~ At this point the navigable line rejoins the parent stream.

The arrangements made for the passage of boats at the Ranipoor and Puttri works, are in every way adapted to security. The Masonry Channel which at these points on the Navigable line is entirely separated from the Stream of the Main Canal (with which except=ing for Lock and supply pur=poses it has no connection what=ever) not only renders the approach to the Supr passages, and the descent to the locks, convenient, but places boats and rafts in their passage ~~along this Navigable Canal~~, out of all danger. ~~Whatever~~

I may here remark that the progress of these extensive works which the Changes in=volved, was greatly facilitated by the use of Water Conveyance from the Canal head downwards, and in the Cheap and ready sup=ply of boulders or river Stone, which

which this mode of conveyance introduced on the works. The Canal ~~Such was~~ excavated for this pur=
=pose, was a mere Channel ten feet wide formed in the bed of the main Canal, and carried a supply of water brought down from the branch of the Ganges which passes under the Town of Burdwan. My original intention was to have kept this an open line for the supply of material to all the works as far as those on the Rutmoo River, for which it was in the high=
=est degree appropriate; circumstances however, prevented the carrying out of this intention to its fullest extent, and the advantage of water carriage was limited to a supply of material for the Rampoor, and other works which were subsequently constructed. The benefits gained however by this limited use of the Canal were great, and in the difficulties and delay in land carriage, of the highest importance; the intro=
=duction moreover of a constant supply of water on the surface of a Country where the Springs were at great depths, was not only a great convenience to the workpeople in providing water for the pur=
=poses of Cooking, drinking &c., but it kept up a constant supply for the brickfields, there=
=by facilitating the manufacture of bricks; and, finally, what was in my estimation of infinitely greater value and importance, it provided an unbounded supply

for

for the Bricklayers in laying the bricks into the work with mortar thoroughly mixed, and with bricks and mortar thoroughly moistened. This ready, although artificial supply of water, in fact, enabled us to ~~do that~~ meet a part at the Ranipoor, which at the Solani and Puttri works, the water from the Surface Springs ~~supply~~ naturally provided for ~~those~~ -

The works, ~~therefore~~, from the Ranipoor to the Rutmoo Torents, ~~on that line which lies to the West of those from the Regulating Bridge at Ranipoor, of which I have before given a Summary,~~ consist of

1st The Ranipoor Superpassage with a waterway of 200 feet in width, connected with Falls No 1, ~~having~~ a drop of 9 Feet in the bed of the Canal

2 - The Falls No 2. with a drop of 9 feet

3 The Falls No 3. with a drop of 9 Feet -

4 The Selimpoor Inlet, 150 feet opening. -

5 The Puttri Superpassage with a waterway of 300 feet in width, connected with Falls No 4, ~~having~~ a drop of 9 feet in the bed of the Canal

6 - The Badshahpoor Inlet 50 feet opening -

7 The Rutmoo Dam and Inlet with Escape of 800 feet ~~and~~ with a Bridge for the pur-pose of Regulating the + Canal

canal supply; and of cutting off the Canal stream from its passage onwards towards the Peeran Kulleen Excava-tion and the Solani Aqueduct: together with a Bridge for Cross Communication North of the Works

8 Line of Navigable Canal from the Dowalapoor Bridge to the Tail of the Puttri Sapr-passage.-

From the Putmoo Regu-lating Bridge to the high Land of the Doab, the Canal runs in an uninterrupted straight line passing between the Village of Peeran Kulleen and the Dingah; between the villages of Bajoobeni and Maheewa; and reaching the high land immediately to the East of the Town of Roorkee; from thence by a curve to the left, which Commences at the terminal point of the Aqueduct, the Channel proceeds in a Straight line to the Assoffnuggur Falls at which point the 1st Divi-sion terminates

The deviations from the ori-ginal design on this portion of the Canals Course (laying aside building details which will be referred to in their pro-per place) consist entirely in a reduction to the slope of the bed; the original plan was, as I have before said, to continue the slope in an uninterrupted

line

line of 18 Inches per Mile: from the Ranipoor works to the flooring of the Rutmoo Regulator, this Slope has been considerably modified, and a similar modification has been practised ~~onwards~~ in advance; the bed Slope of the Canal having been on the line which we are now describing reduced to 15 Inches per Mile, that is to say, from the flooring of the Rutmoo Regulator to the flooring of the Roorkee Bridge, there is a declivity of bed equal to 15 Inches per Mile: Onwards to the Sill of the Falls of Passage (to which point it is necessary to continue the Series to bring under review the Effectively operative slope on the Aqueduct works) the fall on a distance of 21202 feet is equal to 4.4 feet or 1095 feet per Mile. The Section of the Canal on its transverse axis corresponds with that given in detail under the Head of "Excavation." In a general way, however, it coincides with that figured in Diagram ii. On leaving the Regulator the Canal Channel on a length of 5000 feet, passes through the Khadir or low land of the Rutmoo River, it then enters the Peeran Kulleem Ridge, an Elevated tract of land which I have before described as extending from the steep slopes near the Town of Kheri, and terminating at Peeran Kulleem, where it overlooks the Khadir lands, either in abrupt precipices formed by the inroads of

of the Rutmoo Torent, or in un-
=dulating ravine, slopes con-
=siderably elevated, over the low
country which lies on three sides
of it. - The length on which the
Canal takes its course through
this ridge is equal to, 10700 feet
the mean depth of Excavation
being 31 feet, and the Maximum
37 feet; at the point opposite
the village of Peeran Kulleem
a Masonry Bridge with a water
=way of the same dimensions
as those of the Dowlapoor and
Kumkul Bridges, viz: 165 feet
has been constructed for the con-
=venience of the high road be-
=tween Sahaunpoor, Imli, and
Burdwan; This bridge ~~also~~ con-
=nects the village with the Tem-
=ple, Tombs and Reservoir attached
to the Durgah, and gives accom-
=modation to the Multitudes
that assemble during the months
of March and April at a fair
~~which is~~ held at this place,
~~and~~ which, although on the high
road to the Head Quarters of the
Brahminical faith, is ~~solely~~
~~exclusively intrinsically~~ Mussulman.
The Section of the Canal at the
point where this bridge is con-
=structed is with the exception
of that at Gurh and Syndbal,
the deepest on the whole line
of Works, the perpendicular
depth from the Bridge roadway
to the flooring on the Canal
bed being equal to 37 feet; ~~and~~ there
are flights of steps arranged on
its upstream side, for the purpose

of

of ~~offering accommodation to~~ the community with providing
~~the Community, to~~ means of access to the Canal Water
- there are also side or towing path
passages to this Bridge, the
left one being the line of rail-
=way communication between
Roorkee and the Rutmoo
works. This work is entirely
built of brick Masonry, and
its foundations were in some
measure interfered with by
Springs

On the approach of the
Canal Channel to the Villages
of Bajoohera and Maheswa,
the line is crossed by a hollow
which is connected with an ex-
=tended line of Ravine ~~which~~
running back to the distance of
3000 feet into the high land,
which constitutes the Peeran
Kulleen ridge; the drainage
of this line passed through the
hollow which is intersected by
the Canal, and fell into the
Khadir close under the Village
of Bajoohera; this drainage
has been got rid of, by making
an artificial Cut from the hollow
on the right of the Canal, and
giving an escape for the water
to the west of the Village of
Maheswa. -

From the point above des-
=cribed the works of the Solani
Aqueduct commence, the hollow
in question having on both sides
of the Canal, Channels of escape
built in connection with
~~Supplied to~~ the Aqueduct Terminus
and formed through the Embank
=ments

=ments; these Channels are in
with 100 feet with masonry
floorings and flanks, they are
filled in with soil of a light
description, and are hardly to
be recognised excepting in the pro-
=jecting steps of masonry which from their flanks; their
especial object is to relieve the
Aqueduct in cases of extreme
emergency, and their uses will
be fully described hereafter. From
these as they may be termed
"blind" escapes, the down stream
flank of which rests on the
upper Terminus, the Canal
passes the Solani valley in a
Channel whose base is 150 feet
in width, between Revetments
designed in the steps fashion
~~which is adopted~~ as used by the Natives
of India in their Ghats or bath-
=ing places. At a point not
altogether centrical and nearer
Roorkee than Mahewun, the
Solani River is passed by a
series of 15 Archways 50 feet in
width each. The level of the floor-
=ing of the Aqueduct which crosses
the River and upon which the
Canal water is carried, is 21½ feet
above the bed of the Solani which
runs below it; and this 21½ feet
may be considered the maximum
difference of level between the bed
of the Canal, and the surface
profile of the valley on the whole
length upon which the Aqueduct
passes.

The total length between the
extremities of the Termini is
15687 feet, or 2 Miles 7 Furlongs 507 feet

of

of which that portion of the bed which passes over the Solani River and which is 932 feet in length is of Masonry, and the rest of earth. Cattle Ghats and bridges of cross communication act as the terminal features of this Aqueduct.—

From the lower extremity or Terminus at Roorkee the Canal Channel passes on the highland of the Doab to the Assoffnugger Falls by rather an abupt Curve projected to the left on a radius of 6617 feet; this Curve commences immediately on leaving the Masonry of the Aqueduct, and on its concave or right side is protected by a revetment of Masonry which continues on a length of 3200 feet, the whole distance from the Aqueduct Terminus to the Sill of the Falls of Assoffnugger is 21202 feet in length; and the actual slope of bed from the flooring of the terminal Bridge at Roorkee to the Sill of the Falls is 4·4 feet, The transverse section of Channel corresponds with that before figured in Diagram II.

The reduced ~~velocity of~~ slope upon which the Channel runs between the Bridge at Roorkee, and the Sill of the Assoffnugger Falls, has been designed with a view of protecting the bed of the Channel in its course over the Solani Valley:- The flooring of the Aqueduct itself which is 3404 feet on the

the upstream side of the Rookee Bridge and which to correspond with the slope of 15 Inches p/m. Mile, ought to have been laid 8 Inches above that of the Bridge, is laid on the same level,* so that on this point as well as on the whole line of the Aqueduct channel there will be a tendency to back water, consequently and to a relief ~~consequently therefrom to~~ the action of the Current upon the bed; the arrangement of the slopes which I have just described will be best understood by a reference to the longitudinal Section of the works in this neighborhood, they appear to me to be Eminently advantageous to the interests of the works, in this rather ~~delicate~~ portion of their course over a long line of depressed valley.—

It will be interesting at this point, and before closing my remarks on the works of the 1st Division, ~~on those "ex-~~ ~~"tending from the Ganges River~~ ~~"to the high land of the Doub~~ ~~"at Rookee"~~ to ~~bring under~~ shew at one ~~One head~~ view the effective slopes of the Channel; these slopes altho somewhat irregular in detail (an irregularity which has been ~~described as~~ designed for specific objects) are on long lines very distinctly marked, and as easily divided by the constant recurrence of Masonry descents. ~~The descents~~ ~~which~~ lead to abrupt changes of level, and to series quite in slopes dependent

* Actually 2 Inches below. 4/7 nov.

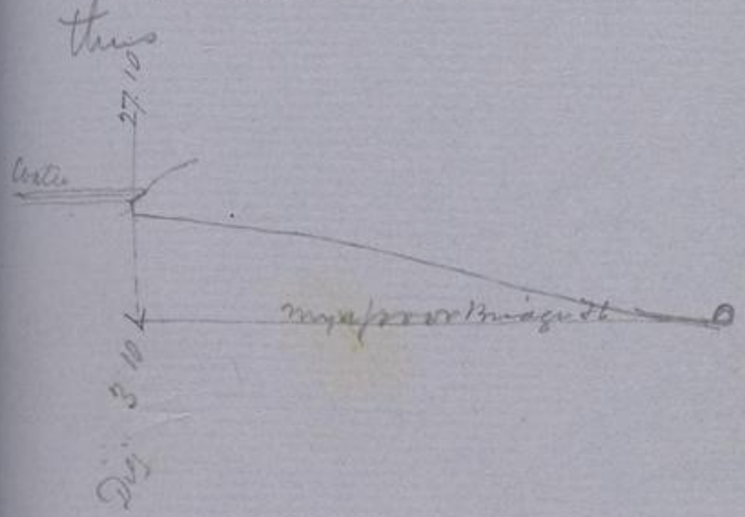
dependent of each other. These long lines or Series may be thus tabulated

Locality	Length		Fall
	Miles	Feet	Ft. Inches & 10ths
From the Ganges to the Head of the Falls at Ranipoor	7	4839	32..9·4

the detail of the above slope may be thus given.

Locality	Length		Fall
	Miles	Feet	Fall, Inches & 10ths
From the Ganges to the Flooring of the Myapoor Regulating Bridge	2	4190	21..0·0 ×
From the flooring of the Myapoor Regulating Bridge to the flooring of the Kumkul Bridge	1	4347	3..8·0
From the flooring of the Kumkul Bridge to the flooring of the Sewalapoor do.	1	4155	2..9·8
From the flooring of the Sewalapoor Bridge to the Site of the Ranipoor Falls.	1	2707	2..3·6
Total	7	4839	32..9·4

× This Fall is the head of the Cut



With the exception of the lower 4 Miles the whole of this distance is passed on beds of Shingle and boulders, that portion of it which extends from the Ganges to the Myapoor Regulator being an old cleared out bed of the River, perm-anent and compact, and composed of Shingle mixed with the largest description of boulders. The effect, therefore, of the forward movement of Material in equal-izing the slopes on this extended line, will, it may be supposed, be a very gradual process; the nature of the bed, however, gives a security to its efficient main-tenance. —

Locality	Length		Fall
	Miles	Feet	Fall, Inches & 10ths
From the Tail or lower level of the Falls at Ranipoor to the Head of the No 2 Falls	1	4462	1..11·3
From the Tail or lower level of the No 2 to the Head of the No 3 Falls	"	2696	0..8·0
Carried over	2	1878	2..7·3

Brought over	2	1878	2 .. 7·3
From the tail or lower level of the No 3 to the Head of the No 4 Falls	2	1403	2 .. 8·7
Totals	4	3281	5 . 4·0
From the Tail or lower Level of the No 4 Falls to the Sill or Head of the Falls at Assoffnuggur. —	12	5240	15 .. 6·1

The detail of the series last given may be thus explained.—

Locality	Length		Fall
	Miles	Feet	Feet. Inches & 10ths
From the Tail or lower level of the No 4 Falls to the flooring of the Dhumoorie Bridge	3	219	3 .. 8·3
From the Flooring of the Dhumoorie Bridge to that of the Rutmoo Regulator	"	1429	0 .. 5·5
From the Flooring of the Rutmoo Regulator to that of the Peeran Kulleen Bridge	1	1393	1 .. 2·9
From the Flooring of the Peeran Kulleen Bridge to that of the Mahewun Bridge	1	3349	2 .. 3·7
From the Flooring of the Mahewun Bridge to that of the Masonry Channel over the Solani River	2	614	3 .. 6·9
From the Flooring of the Masonry Channel over the Solani River to that of the Roorkee Bridge	"	3404	Rise 0 .. 2·0
From the Flooring of the Roorkee Bridge to the Sill of the Assoffnuggur Falls	4	82	4 .. 4·8
Totals as above	12	5240	15 .. 6·1

The composition of the Soil through which the Canal Channel runs from the Ranipoor works downwards, is on the first part of its course, or as far as the head of the Puttri falls decidedly light and sandy; in advance of this there is a great admixture of clay, and the excavation through the ridge of Peeran Kulleen, the greater part of which has been carried out to the soil from form the banks in the Rutmoo valley and the Earthen portion of the Solani Aqueduct, was made through alternate strata, of soil more or less sandy, and unmixed clay, similar to that which is produced in old ponds and reservoirs; the same species of soil existed on the opposite and

Roorkee

Rookee side of the valley, the Solani having clearly worn ~~away~~ its passage through a series of horizontal beds which formerly extended from Rookee to Peeran Kulleeur.-

Both the bed of the Solani aqueduct and the Embankments which are constructed in rear of the Masonry side Revetments, to which they form a backing, are formed, therefore, of soil of a very mixed nature, great care has been taken in its consolidation, and it is supposed that an upper layer of boulders which will be gradually deposited on the earthen portion of the Channel, will in the course of time secure the permanency of bed which is ~~contemplated~~ designed.-

I may observe in concluding this section, that although the demand for Irrigation on the tract which has been described, is comparatively of little general importance, there are lands lying high on the right bank of the Ganges, in the neighborhood and within the limits of the Puttri Forests, that will derive extraordinary benefits from the introduction of water. For the accommodation of these lands, heads for Irrigation have been provided both at Kunkul, and from the Mill reservoir at Bahadoorabad, and although I have not thought it expedient to build heads for Irrigation at other

other points, the means of Irri-
=gation can very easily (and
certainly with greater practical
advantages) be provided hereafter

~~CHAPTER II~~

~~Dakoda Agreement~~

II

II "The Country from Roorkee to
"Nanoon marked by great
"declivity of fall in the surface
"and by its connection with
"Bhoor or tracts of Sand Hills"

It was necessary to enable
me to bring the Slopes of the Canal
bed, and their effects upon the
Solani Aqueduct, fairly under
review, to include in the first
section, that portion of the high
land extending for 4 miles
from Roorkee to the Sill of the
Assofnuggur Falls; the inclusion
is a matter of no importance,
but it is as well to keep it in
consideration, when defining
the limits of country ~~marked~~ so
~~by such a distinctive peculiarity~~ topographically different as that
~~of feature as that which is ex-~~ of which properly belongs to
~~-hibited in the tracts to which~~
the 1st and 2nd Sections ~~are~~
~~limited~~.—

From the uncertainty
that exists as to the amount of
water which will be taken for Irrigation in
the Khadir ~~tracts~~, and the means
that (from its proximity to the
Ganges River) we have of restoring
any quantity of water that may
be so taken, without interfering
with the calculated supply for
the

the lower regions; we may con=
=sider that at the head of the
Section, on the description of which
we are about to enter, the supply
of water is equal to 6750 cubic
feet per second, or to that which
is the theoretical quantity as=
=sumed for the Canal supply
from the Ganges River, without
loss or detriment from either
natural or artificial causes.—
At any rate as this is the specific
quantity upon which the capac=
=ity of Channel, and means for
irrigation have been provided in
advance of Roorkee, it is neces=
=sary for a perfect understanding
of the subject, that the above
quantity should be not only
admitted into the Canal and
delivered on the high land above
mentioned, but that its existence
should be admitted by those
who are either directly or indirectly
interested in the truth and value
of the Calculations. The Quantity lost

The length of Canal which
is included in the Section under
description, or that from Roorkee
to the Village of Narroor is 160
Miles, its Direction both on the
project of 1815 and on that
which (arising from a redistri=
=bution of the branches South
of it) was afterwards determined on
is in every respect similar; con=
=siderable modifications to the
slope of bed, and to the capacity
of Channel, arising partly
from this reduction of slope,
and partly from the redistribu=
=tion of the supply for Irrigation
have

consumed in irrigation between the
Head and the Asoffnuggur Falls will
be comparatively small, and is prac=
=tically speaking of no material impor=
=tance. To leave it out of consideration
however essential to my argument.

have led to changes in the works, but the direction of the Canal alignement is ~~in every respect~~ alike ~~the same~~ in both cases.—

The Project of 1815, gave throughout the whole of this Section, an equable Slope of ben equal to 18 Inches per Mile, the superfluous Slope being disposed of ~~in~~ by four descents of Eight feet each, in masonry falls situated at Doodpoor, (Muhmoodpoor) Baibra, Daoli and Chitowra, the ~~width of~~ water way at each of these falls consisted of six bays ~~each of~~ 25 feet ~~each~~ wide, or a total ~~water way~~ of 150 feet ~~in width~~. For the passage of these descents, lines of navigable Channel, & separate from the main ~~Canal~~ Canals were designed, the departure of which from the Canal and the point of admission into it again were situated as far as possible out of the influence of the increased rapid depending on the proximity of the falls: these lines also were fitted with locks for the convenience of ascent and descent of boats and rafts in their passage ~~along~~ the Canals, and the bridges were designed with Towing Paths, situated under the ~~right~~ left arch, in prolongation of the berm which acted as a towing path on the whole line of the excavated & Channel.—

At a point near the 50th Mile of the course of the main Canal, and near the Town of Daoli (6.

Saoli, a branch was to be taken off from the left, for the purpose of irrigating the lands lying between the Eastkalli Nuddi and the Ganges River; and at the 110½ Mile, it was proposed to take off another branch on the right for the Irrigation of lands in the neighborhood of Tuppul in the Aligurh District. —

The original project therefore, which will be perfectly understood from the above short explanation, consisted in the Section under review of:

1st A Line of Canal with a declivity of bed on an uniform slope of 18 Inches per mile —

2nd Four Masonry descents of 150 feet each in width of waterway, and with a drop of 8 feet on each descent, for the purpose of overcoming the superfluous slope. —

3rd A Branch for the Irigation of the Futtiguh District situated on the left bank of the Canal, and at the 50th Mile of its course, with a Masonry Head at the point of departure from the Main Canal —

4th A Branch for the Irigation of the Bulundshuhur and Tuppul country, situated on the right bank of the Canal and at the 110th Mile of its course, with a masonry Head at the point of departure from the Main Canal

5th Bridges situated on an average

average of every 3 miles, adapted in Water way to the Section of the Canal at the particular point where ~~it was~~ they were constructed, and fitted with Towing paths under the left arch and in pro=longation of the line of bern

6th Three Escapes; two of which situated at Aboo's Canal and at Sanni Khoora at the respective distances of 62 and 69½ Miles on the Course of the Canal were to deliver the waste Water into the West Kalli Nuddi; and one situated at the 141st Mile to throw the waste water into the East Kalli Nuddi at a point opposite the Town of Khooja - Each of these Escapes had a Water Way of 60 feet in width, divided into Six Openings of ten feet each.-

To render the detail above given more distinct, and to enable the reader at once to comprehend the design for the capacity of the main Channel, as well as that for the distribution of the supply throughout its whole course from Burdwan to its junction with the main Rivers, I shall here give, in juxta=position, a Skeleton outline of the project of 1845, and that which was determined on in my letter to Government No 1053, of the 15th January 1850, that, in fact, upon which the works have been executed - The introduction of these

diagrams

diagrams here with a few pre-
=fatory remarks derived from the
above letter, although in some
measure anticipating the mat
=ter of the Section that lies in
advance of Narora, will enable
the reader to form a comprehensive
view of the causes which led to
the changes above that point.

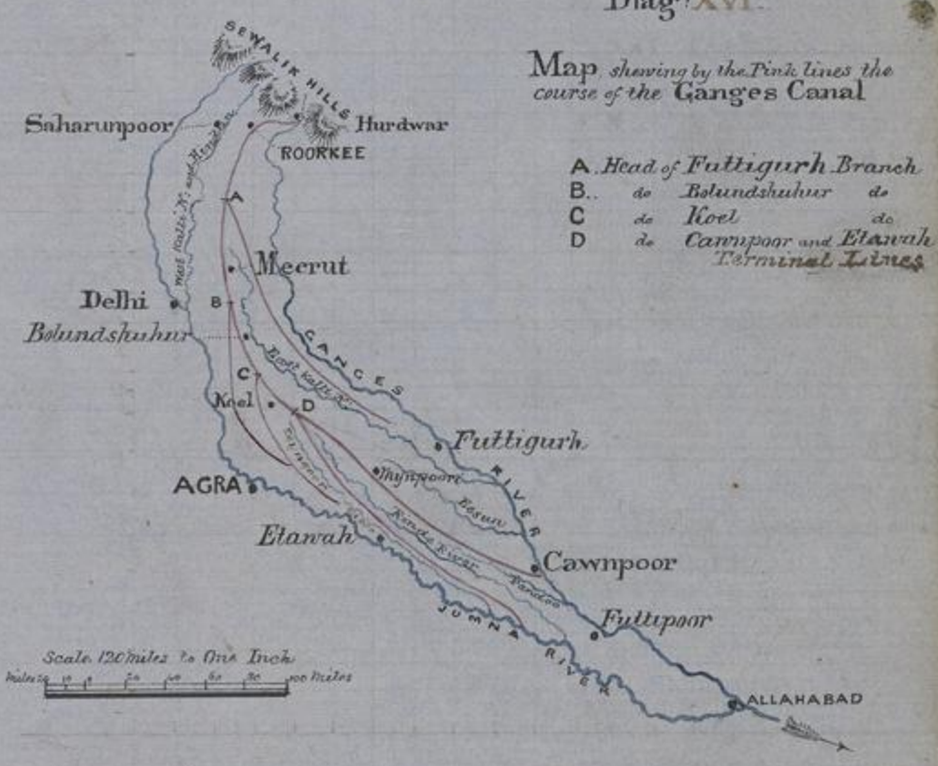
It will be recollected that
there were considerable doubts
expressed at an early period
of the history of this Canal
whether the directions of the branches
as laid down in the original
project through the Cawnpoor
District, were those ~~most con-~~ best adapted
~~-ducive to exhibit in the best~~ for distributing
~~relief~~ the benefits of Canal Ir-
=rigation. The project above re-
=ferred to, placed the main line
in a position running parallel
to and on the left of the Rinde
River until it reached the Jumna
near the village of Sarsi from
this main line a branch was
conducted to the Ganges at Cawnpoor.
From the point of departure of
the Cawnpoor Branch, the data
upon which the Estimate of the
main Canal had been drawn
up, were merely conjectural, the
country it is true, had been exam-
-ined by me both in cross section,
and in a line of longitudinal
levels bearing upon Futtipoor
and Allahabad, but the precise
line upon which operations were
contemplated had not undergone
detailed examination, a proces
~~that had been~~ confined entirely
Price & Co
to

to the country upon which the branch to Cawnpoor was to be executed: on both lines, however, and especially on that which runs parallel to the Rinde, the Cawnpoor District — through which they took their course, was under a high state of cultivation, this being especially the case on the country to the left of the Rinde River. To the right of this River, however, and between it and the Jumna, the condition of the country was remarkably different; from the great depth to which wells had to be carried before Spring water was reached irrigation was unknown, or only partially known in the Ghatumpoor and Jajmow Pergunnas, a tract of country lying at the junction of, and between the Rinde and Jumna, and covering an area of about 400 Square Miles. As a general rule whether from difficulty in procuring irrigation from wells, or from difference in the quality of the Soil, there could be no question that the state of the lands lying to the Right was inferior in an Agricultural point of view to that on the left; the Agricultural formulation was on both sides of the River in every respect the same; the cause of the difference, therefore, was clearly traceable to a want of advantages on one side of the River, which were enjoyed by the people on the other; to a want in fact of the means of Irrigation which in the North West Provinces are the soul of Agriculture.

Under the above consider

=ations, and with results before me derived from detailed Surveys and levels of the lands lying to the Left of the Rinde which were by no means satisfactory; after a personal examination of the lands in question, correspondence with the Revenue Civil Officers connected with the District, and after having entered freely into the Subject with various persons all of whom were more or less interested in the detail of our operations; the design of keeping to the left of the Rinde River was abondoned, and the Canal in its lower portion was laid out in directions more adapted to the demands of the country, and to the economic application of the water for agricultural purposes. This will be better understood by the following diagram, which is a reduced Map of the country upon which the Ganges Canal works were projected. –

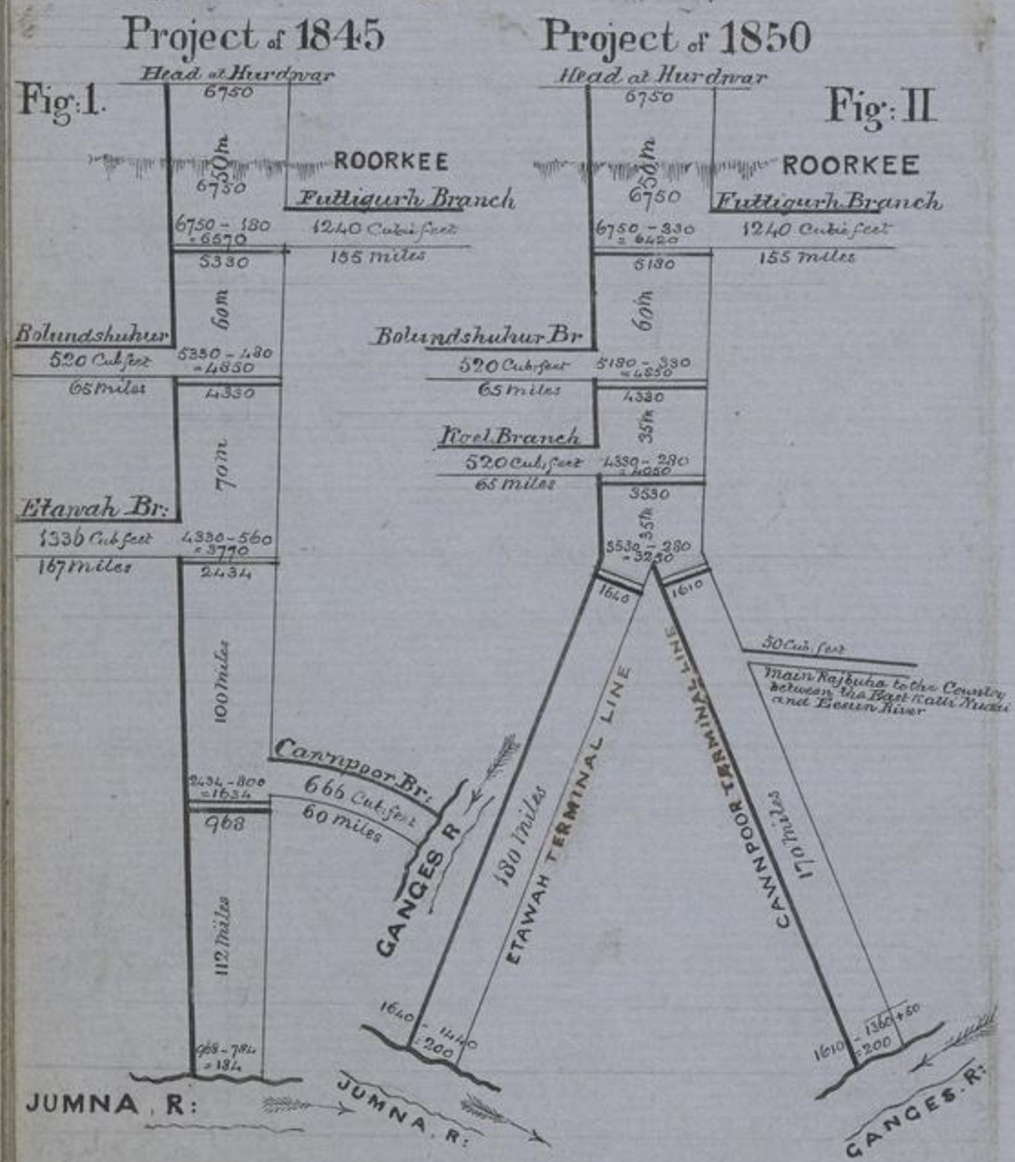
Diag: XVI.



In illustration of the above the following Skeleton outlines will place before the reader the detail of distribution of supply which

which the above changes necessitates

Diag: XVII.



It may be handly necessary to enter into an explanation of the above figures; they depend however, upon the 2nd Axiom of the prefatory remarks on the calculations upon which the original project was based. viz; that from the results of the Delhi and Doab Canals "800 Cubic feet per second "constant is a fair supply for Irrigation for 100 miles in length of "a Canal" and "that that portion "of the Canal extending from "Hurdwar to the village of "Nusseerpoor (27½ miles in length) "may be considered as removed "from the influence of irrigation, "from its passing through Khadir "land in the early part of its "course, and deep digging im- "mediately above Nusseerpoor"

The Canal, E: G: on its reaching

reaching the Regulator at the
head of the Etawah Branch, vide
Figure 1. contains a volume of
water equal to that which it held
on leaving the Bolundshuhur
Regulator minus 8 cubic feet
per mile of the distance between
these Two works; or as is above
shewn it holds 4330 cubic feet
— 70 × 8 = 3770 cubic Feet. From
this amount 1336 cubic feet is
abstracted for the purposes of the
Etawah Branch, the residue, viz.
2434 Cubic feet per Second passes
on to the lower Districts

It will be seen from a
comparison between the diagrams
above shewn, that at this period
of our operations it became ne-
=cessary to remodel the line of
Canal in all its extent. especially
from the head of the Koel Branch,
or from the 145½ Mile downwards;
to use the words of the letter to which
I have before referred. "The chief
"feature of the alteration is this,
"that the main Canal is continued
"in one Trunk to the 180½ Mile to
"the Village of Narroon in the
"Alligurh District, at which point
"it separates into Two branches,
"one bearing direct upon Cawnpoor,
"and the other going to the right
"of the Rinde River - The first
"falls into the Ganges at Cawnpoor,
"the latter into the Jumna above
"the junction of the Rinde. Above
"the fork in addition to the
"Bolundshuhur Branch, a line
"will leave the main Trunk
"for the purpose of irrigating
"the country in the neighborhood

"of

"of Koel, Rattrass, Ferozabad
"and a portion of the Etawah
"District; this line has been de-
"-signated the Koel Branch
"The tract between the East
"Kalli Nudi and the Cesum
"will be partly irrigated from
"a point below the Fork by a
"Rajbaha to which theoretically
"50 Cubic feet per Second have been
"given, and partly from the
"Cawnpoor Branch by Aqueducts
"over the Cesum, the latter being
"a question for after consideration
"and design, when the Canal
"is in working order."-

The above is a digression but its introduction at this place will simplify in a very great degree, the explanation of matter directly connected with the Section of works now under review.-

One of the first points that attracted my attention on rejoin-ing the Canal works early in 1848, was the result of the Ex-cavations as far as they had been carried on the high land from Roorkee downwards, With the exception of well marked tracts of Bhoor, or sand hills, the Superficial soil was good, in some places of a very tenacious quality, and its general character was equal to that which we had met with in the Excavations on the Eastern Jumna Canal lying on similar parallels: this Character, however, proved to be entirely deceptive, the good soil

merely

merely overlaid sand; and throughout the whole course of the excavations, this sand had been laid bare to an extent that rendered the question of the slope of the bed and the design of the different Masonry works, as originally proposed, matters for serious consideration. The slope of 18 inches per mile was under any circumstances excessive, but its maintenance on a good soil aided by artificial expedients, was by no means considered to be an impossibility or ~~at~~ likely to involve expenses of an extraordinary nature; this could by no means be the case when the water was brought in direct connection with sand, or with the lighter varieties of soil that the admixture of ~~this~~ sand leads to; nor could the design for the Masonry works be considered appropriate to a channel where, although the surface of the bed might exhibit some trifling signs of durability, every foot in depth of excavation for laying in the foundations plunged deeper and deeper into sandy soil. The necessities for modification not only in width of waterway, but in depth and solidity of foundations became, under this evil apparent, and, although, from the advanced state of some of the works in the neighborhood of Munglour and Libunberi a reduction of slope became somewhat inconvenient, as necessitating an alteration of work which had already been done, I determined at

at once to remodel the whole of the slope on a reduction of 3 inches per mile from the Roorkee Bridge to Nanoon, to increase the waterways of the bridges and falls, and to provide for all the contingencies which the connection of Sand and Springs with foundations, and the protection of works under such circumstances, called for.-

With a view to putting the above intentions into immediate execution, and as the levels on the whole line had been accurately determined; a point (to which I have before alluded, viz: the sill of the Asso Jnuggur falls) was fixed upon, from which an entirely new series of slopes was to be commenced.- Asso Jnuggur was convenient as affording a good and commanding head from whence, to begin our lines of Irrigation; it was conveniently situated to Brick manufactories, and it was precisely the point on the course of the Canal from whence under any circumstances, the Nussiepoor Irrigation would have derived its supply.- The site of the Asso Jnuggur Bridge, which was originally intended as a line of Country cross communication, was fixed upon, therefore, as the starting point for the new series of levels; a descent of 8 feet in Masonry was here established, and its upper platform or sill (before described as fixed determinately with reference to the works on the Solani aqueduct) was made a Zero from whence the

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the new levels were to be carried.-

The reduction of the slope of the Canal bed from 18 to 15 Inches per Mile led to an in-=creased number of falls to enable the superfluous slope of the country to be disposed of; these Falls were dispersed throughout the whole line, but their succession was more rapid in the Saharunpoor, Mozuffurnug-=gur and Meerut Districts; whilst on the remaining seven-=ty Miles for the Country ~~which passed through~~ the Districts of Bolundshuhur and Alligurh) ~~extended on a profile~~ corresponded in a great degree with that of the new levels of the Canal bed, until it reached the neighborhood of the Huts on which the Rinde and Eesun Rivers took their rise; at this point, a somewhat abrupt des-=cent in the surface of the country led to a corresponding descent in the Canal levels.

The Project under this revised Plan consisted of an uninterrupted slope of 15 inches per Mile, with Masonry des-=cents at the following places

			waterway
N. S. of Nuggur	Descent of 8 Feet		200 Feet
Muhmoodpoor	Do.	8 "	200 "
Delra	Do.	8 "	200 "
Gauli	Do.	8 "	200 "
Chitowra	Do.	8 "	200 "
Sulawar	Do.	8 "	150 "
Bhola	Do.	8 "	150 "
Dasna	Do.	8 "	150 "
Dulra	Do.	5 "	100 "
Timra	Do.	5 "	100 "

a

a total declivity of 7½ Feet being overcome by masonry. The water way on these Falls it will be observed had been increased, ~~from that which had been formerly designed~~; and in the case of the substructure and foundations (especially at Assoffmuggum and Muhmoodpoor) ~~not only had~~ a necessity this arisen only for extraordinary depths, to counteract the effects of the sand in which they were imbedded, but for an unusual quantity of masonry to meet this excessive demand for depth.

while the substructure & foundations generally but especially at Assoffmuggum & Muhmoodpoor were of necessity carried to excessive depths to obviate the risks of accidents from the nature of the sand in which they were embedded, & these depths further required that the masonry should be proportionally augmented in dimensions.

Additional waterway was obtained by ~~a~~ removal of the towing paths which obstructed ~~a~~ portions of the left bays of the Bridges as they were formerly designed, and by substituting in some instances for the structures of solid masonry a pathway under the arch supported on an Open Timber frame work; in others ~~bridges~~ a Towing path ~~Archway~~ passage, was constructed through the wing walls of the bridge ~~connected with the abutments~~, and in prolongation of the berm or towing path of the excavated Channel: but in all cases throughout this portion of the Canal, where the works were connected with sand, both Bridge and Fall floorings were covered ~~both~~ in front and rear by ~~an~~ aprons of heavy material consisting of either blocks of Kunkur, or of Brick masonry protected by lines of Sheet piling: the flanks, moreover, of all these works were well protected by lines

lines of piles

The above will explain the alterations which had been made in the bed slopes of the Canal, and the method that had been adopted in overcoming the dif=
=ficulties of superfluous fall=
We now come to the Topograph=
=ical features of the country, with a detail of the different works that have actually been constructed: and that this may be more distinctly placed before the reader, I shall divide the description into sections, com=
=mencing at the Head of the high or Bangor land at Roorkee

19th to 40th mile

The Canal after its passage across the Solani River and its arrival at Roorkee, makes a turn to the left and continues on a bearing almost due South for a distance of about 20 miles, until it reaches the neighbor=
=hood of Bela; on this line it runs parallel to and between the high bank overhanging the Khadir and the Seela Nulla, a shallow depression that acts as a tributary to the West Kali Nadi. ~~The~~ Its position, with regard to these two natural boundaries, is by no means centrical=
as a general rule it is nearer the high bank, and in the vi=
=cinity of Noorneggur, Dimat, Rumbhera and Jogholpoor approaches to within 1/4 miles of the edge of the Khadir. Through=
=out the whole of this tract the ~~Surface~~ is marked by undu=
=lating ridges of Sand either

Skirting

skirting the edges of the Rivers,
or throwing out ramifications
transversely, but in every case
where they appear, they ~~add greatly~~ does it by
~~to the Picturesque~~ of the ~~Scenery~~
barren as it is, and ~~uncultivated~~
either by the presence of foliage,
or excepting during the rainy
months by the slightest appearance
of verdure. The line of Canal
crosses three of these ridges; the
first almost immediately after
leaving Roorkee, the second in
the neighborhood of Toghulpur;
and the third, near Belra;
although this tract of country
is intersected by sand ridges as
I have above described, and
marked by extensive areas of
land on which rain Crops
only are planted, it is by no
means an ill cultivated nor
a poorly populated ~~Country~~ region;
there are numerous large Towns
well wooded with Mango and
other fruit trees indigenous to
this part of India, in the vici
=nity of which the Cultivation
is very extensive, but the whole
is what is designated Barani,
that is to say, dependant on
rain for Fertilization: the wells
which vary in depth from 66·36
to 216·71 feet are too deep for
Agricultural purposes, and it
is only now and then, when
small patches of garden land
lie in the proximity of ponds
or natural hollows, that the
rain water collected in them
is used for the purposes of Ir=
=rigation

The slope of the Surface of the Country

on

on the 20 Miles running from
Roorkee to Belra may be es-
=timated at 46 feet, or 2·3 feet
per Mile; as a general rule &
there is a transverse slope from
the edge of the bank to the bed
of the Seela nulla, but the in-
=termediate land upon which
the Canal takes its course, is
sometimes nearly horizontal,
this is especially the case at
Roorkee, as well as at Toghulpoor
and Belra where the high land
lying between the ~~high~~ Bank
on the East and the Sand ridges
which run parallel to the Canal
on its West, has very little variation
in profile; the line of Canal how-
=ever, although keeping as close-
=ly as possible on the backbone
of the Country, must, as will
be understood from the transverse
slope before mentioned, interfere
in some degree with the local drainage
~~of the Country~~; this has been
remedied in the neighborhood
of Munglour and Libunheir
by a Cut made into the Khadir
of the Ganges, and it will be
evident from the position in
which the works are situated,
high above the low lands &
which run within a few miles
of them, that inconvenience &
arising from want of drainage
can only be attributed to a
want of Channels of Escape
for the making of which Nature
has provided every facility. On
the approach of the Canal to

Belra

Belna, it takes up its proper position on the watershed of the Country

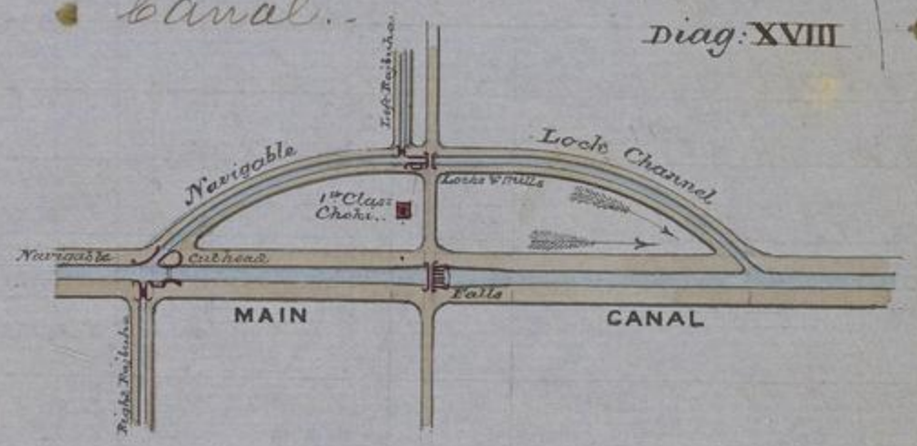
The depth of Excavation throughout the whole of the Channel from Roorkee to Belna is greater than that of the cul-culated maximum high water of a full Canal supply excepting in the neighborhood of Joghulpoor, where a depression of the Country on a length of 4900 feet has led to Embankments; the minimum depth of excavation on this depressed line is equal to 4·18 feet.

The Works on this line consist of:

1st The Ass of Jnuggur Falls, with a Water way of 200 feet. over the Sill or Waste-weir. A Navigable Channel which leaves the Main line of Canal at a distance of 3500 feet above the Falls, on the left, and runs parallel at a distance of 1000 feet, rejoins the Main Canal again 4080 feet below the falls; the head of this line is protected by Masonry Works, with plank Revetments on each side of the Main Canal, fitted with iron rings and appliances for the Establishment of a bridge of boats over the Main stream, the object of this bridge being partly to prevent craft passing down the Canal from coming within the influence of the Overfall, partly to give a line of cross communication, and partly to give head water to

to both the Navigable Channel and to a Rajbaha or main water course Head which is situated immediately above it on the Right bank. Locks with a bridge the axis of which corresponds with that of the bridge over the Falls are constructed on the Navigable Channel for the convenience of passage, and above the Locks and connected with them is the Rajbaha head for the irrigation of the Country on the left. Corn Mills are attached to the Waste Channel of the Lock Chamber, and a 1st Class Choki is built in the Island formed by the Main and Navigable Channels. For a full description of these works, the Atlas and the Chapter devoted to the details of construction must be consulted; but the introduction in this place of the following diagram will ~~exhibit to~~ place before the reader the general lining out of the works of this description throughout the Canal.

Diag: XVIII



2nd Bridge at Mungloor with a Choki building of the 2nd Class; this Bridge has 3 Bays.

with
~~and~~ a Roadway of 18 feet,
Bays of 55 feet each, and has attached to it both on the up and down Stream flanks, flights of Steps for the convenience of the native Community.—

3rd Bridge at Siburhee with a Choki building of the 2nd Class. on the same design as that at Munglour.—

4th Bridge at Mundorli the foundations only of which have been built.—

5th Falls and Works at Muhmoodpoor similar in every respect to those at Assoffnuggur

6th Bridge at Dimat, similar in every respect to that at Munglour

7th Bridge at Toghulpoor with a Choki building of the 2nd Class. on the same design as that at Munglour.—

8 Falls and Works at Belra. similar in every respect to those at Assoffnuggur, with exception to the Choki ~~buildings~~ which is of the 2nd Class; and of the Tail Sluices which are built on the original design vide Plate XXVIII of atlas—

9th Bridge at Belra with a Choki building of the 1st Class.

In advance of the Village of Belra, the line of Canal makes a slight turn to the right, increasing in distance from the high bank of the Ganges, and gaining a more central position between that bank and the lowlands connected with the West Kalli Nuddi, this inclination to the right or to the Westward increases on

40 lbs to 60 lbs Mile

on its approach to the Town of Khutowli, immediately North of which and to the Eastward, it passes the heads of the East Kalli Nuddi which from henceforth separates the Canal from the Ganges River. The distance be=-tween the East and West Kalli Nuddies at this point is about 8 Miles, through which the Canal passes very nearly centrically

The features of the Country throughout the above tract which extends for 20 miles, are not unlike those which I have before ~~explained~~ described; there is much Bhoor land, and to the West of the line, and between it and the Valley in which the West Kalli Nuddi runs, there are a succession of ridges; the excavations therefore, both for the Channel and for the foundations of the Masonry works were sandy throughout; brick soil was with difficulty met with, and the early comple=-tion of the numerous and ex=-tensive Masonry buildings on this line, may be placed to our success in collecting bricks from the extensive ruins of Chitowra, and other old Towns which are the remnants of a period when the Mozuffurnuggur District was governed by Zalitha Khans family. —

The longitudinal slope of Country over the 20 miles above referred to, is 32 feet or 1·6 feet per Mile; the Transverse slope is from West to East, but the line of Canal runs high and is well

situated

situated with regard to the Wate
=shed.—

From a point at the 50th
Mile of the course of the Canal,
a branch for the irrigation of the
country lying between the East
Kalli Nudi and the Ganges,
leaves the main line on its left
or East bank; at the period that
I am writing (1833) nothing has
been done further than the pre-
=liminary surveys, lining out,
establishing bench marks or
fixed points of level, and (as
far ~~within the reach of the~~
~~main Canal~~, as supervision
can be provided for) brick making
The detail of the project for this
line will be found elsewhere.—

To the Eastward, and at
the village of Untwara which
is situated nearly opposite the
60th Mile of the course of the
main Canal, the East Kalli
Nudi rises. Tanks or large ponds
have been excavated at its im
=mediate head, which during the
hot months of the year are perfectly
dry: this line of drainage, which
ultimately forms a very extensive
river, is immediately below these
tanks a mere shallow ill defined
Nulla, running through low,
grassy, and untidyly cultivated
lands; it gradually however ex-
=pands ~~itself~~, and at a point
in its course at some distance
~~before it had reached~~ above the Town of
Bolundshuhur it becomes a
perennial stream, running in
a wide and well marked valley,
which continues increasing in
size

size and importance until pass-
-ing under the ruins of Kanoge
it reaches the Ganges near the
village of Muhdeepoor in the
Furruckabad District - As this River
runs parallel to the Ganges Canal
through the greater part of its
course, and is a receptacle for
a good deal of its escape water;
its influence on the works, as well
as on the drainage connected
with them, gives it an important
place in the history of the Canal

The depth of excavation of
the Canal channel from Belra
to Khutowli is sufficient for all
the ~~Canal~~ required purposes - The maximum
depth from the surface of the
Earth to that of the water in
wells during the cold weather ~~was~~ is
by observation equal to 67·69 feet,
the minimum 29·22 feet -

On the 20 miles above described
and from the Bridge at Belra
the following works have been
constructed: -

1st Bridge at Bhopa - on
the same design as those which
have been before described, with
a waterway of 165 feet & 2nd Class Chokee

2nd Falls and Works at Paoli
corresponding in every respect
with those at Assoffnuggur,
with exception to the Choki
building which is of the
2nd Class. -

3rd Head of the Futtiguch Branch
this work consists of a bridge
with 9 Bays of 20 feet each
over the Main Canal, and a
bridge of 4 bays of 20 feet each
over the head of the Branch

connected

connected by a line of Curved Revetment, resting upon a redan shaped platform which projects its acute angle towards the point of separation of the main stream and the branch; the sides of this redan con-=sist of flights of steps or Ghats which are approached from the higher levels by stairs ~~which are~~ centrically placed on the Curved Revetment; both these Bridges are fitted with Shut-=ters and planks, and the necessary appliances for Re-=gulating the water. A 1st Class Choki is attached to these works, its site within the angle formed by the de-=parture of the branch, having been ~~determined~~ established on a line bisecting the angle of se-=paration of the two Streams. The following Diagram re-=presents the lining out of these and other similar works on the whole line of canal

P. V.

Diag: XIX.

4th Bridge at Dukheri with Towing path arches in the flanks and a Choki building of the 2nd Class. The water way 165 feet in width consisting of 3 bays of 55 feet each (vide Atlas Plate LI)

5th

5th Bridge at Jansuth, similar to that at Dukheii, but Roadway 20 feet wide. 2nd class Choki attached.

6th Falls and Works at Chitowra similar in every respect to those which have been before described

7th Bridge at Surai, similar to that at Dukheii, and a 2nd class Choki attached

60th to 80th Mile

The course of the Canal proceeds ~~towards~~ direct from the Mouth of the East Kalli Nuddi and Khutowli ~~on an even bearing~~, until it approaches the Town of Sirdhumna where it inclines a few degrees nearer to the South thereby avoiding ~~by these means the~~ contact ~~in~~ at the most exaggrated part of ~~its course~~ the ridge with a line of sand hills, which ~~in some measure form a~~ partially Curve round the Northern side of the Town:- the East and West Kalli Nuddies form the Eastern and Western boundaries of the Canal Tract, the line ~~of~~ kept very nearly however keeping somewhat nearer the latter; the West Kalli Nuddi in the latitude of Sirdhumna has joined the Vindum River, which by its westerly course, and by a consequent departure from the bearing upon which the East Kalli Nuddi runs, places the Canal on a wider field, the transverse distance between the two Rivers being at this point equal to 11½ Miles. The Slope of the Country on this Section of 20 Miles is 29·5 or 1·47 feet per Mile, the transverse width varies from 8 to 11½ Miles, and the

Slope

slope which ~~may be considered~~ as slightly tends to the East, does not militate against the effective position of the Canal, ~~which is~~ that taping far as the regularity of alignment would admit of it) fairly on the watershed. The Bhoor land with well defined sand hills is conspicuous on the westward; and near Sidhumma, the Canal cuts a ridge which intersects the country lying north of the Town: the soil however, through which the Canal Channel is excavated is of a better description than that which had before been met with, although it is still light, and in the region of the foundations of the works almost pure sand. The Bindum as well as the ~~West~~ East Kalli Nuddi have by this time become formidable rivers with deep sections and widely extended valleys or Khadirs. Immediately opposite the Town of Khutowli and on the right bank of the Canal at a point 62 Miles from the Head at Myapoor, is the Khutowli, or No 1, Escape, connected with the west Kalli Nuddi by an excavated Channel of 60 feet in width at its head; the distance from the Canal at this point to the River is $3\frac{3}{8}$ Miles, and the difference of level from the bed of the Canal to that of the River is ~~27·78~~ 29·21 feet; the width of waterway for the passage of waste water is 60 feet divided into 10 Openings of 6 feet each (Vide Atlas Plate No XXXVII) Across this line of Escape Channel and

and at a distance from the Canal of 6024 feet the Main Western + Rajbaha is carried over an Aque-duct, connected with a bridge of cross communication, to the floor of which a masonry descent for the purpose of overcoming 8 feet of the superfluous fall is attached; it is not intended to anticipate the natural effects of retrogression of levels on this Escape Channel by building fur-ther works; it has been considered more economical, to watch the effects of the Current and to apply remedies, when such appear to be necessary: As this Escape is the most Northerly one of those situated on the high lands be-low Roorkee, its position is one of decided interest.-

At the 69th Mile, and not far from the village of Dowalaguh the Canal Channel intersects the ancient ~~line of~~ Canal of Mahomed Abdoo Khan - This old work has been described in the early part of this paper; marks of excavation ~~com-mence near the village of Rampoor on the West Kalli Nuddi, and con-tinue~~ in an oblique direction across the Canal to the head of the Khoodara (one of the nu-merous tributaries connected with the East Kalli Nuddi which passes through the Cantonment of Meerut - At this point of intersection No 2 Escape, equal in dimensions to that at Khutowli has been built, and a Channel excavated on the old line of Aboos Cut towards Furreedpoor on the West Kalli Nuddi

The

Commence at two points on the west Kalli Nuddi, the most Northerly one near the village of Rampoor, the other from Furreedpoor a village lying about six miles to the South; these two lines form a junction on the right and afterwards proceed

1445
285

The distance from the Canal to the River is equal to 7 Miles, and the difference of level from the bed of the Canal to that of the River is 23 93 feet; the width of waterway and arrangements for its passage by the Western Rajbaha, with those for anticipated retrogression of levels are the same as in the case of the No 1 Escape at Khutowli. At the site of this work is a 2nd Class Chouki for the accommodation of the requisite Establishment its situation, however, is 7950 feet distant from the Uterna bridge, and, therefore, not so conveniently placed as it ~~might have been~~ had it been in immediate connection with a passage of cross communication

The depth of Excavated Channel on the line from Khutowli to Sirdhuna is sufficient for all Canal purposes. The maximum depth from the surface of the earth to that of water in wells is by observation during the month of May, 44·63 feet, and the minimum 14 feet.

On the 20 miles above described, and from the bridge at the village of Surai before noted, the following works have been constructed

1st Bridge at Khutowli, on the High Road between Meerut and Saharunpoor, on the same design as that at Mungloor, but with a roadway of 24 feet in width: There are Ghats

or

or flights of steps on the down stream face of this bridge, and the upstream side is protected by curved wings

2nd No 1, or Khutowli Escape into the west Kalli Nuddi, with 60 feet water way, divided into 10 Sluices of 6 feet each.

3rd Bridge at Sutheri similar to those at Dhukheri and Jansut with a water way of 165 feet divided into 3 arches of 55 feet each. 2d Class Choki

4th Falls and Works at Sulawur similar in every respect to those which have been before described but with a width of waterway reduced to 150 feet.

5th No 2. or Aboo's Escape into the west Kalli Nuddi with 60 feet waterway, divided into 10 Sluices of 6 feet each. with a 2nd Class Choki attached

6th Bridge at Uterna similar to that at Sutheri with 2nd Class Choki attached

7th Bridge at Sirdhunna Roadway 25 feet in width similar to that at Khutowli with Ghats or flights of Steps built precisely on the same model. attached to this bridge is a 1st Class Choki

8th Bridge at Nanoon with 150 feet waterway in 3 arches of 50 feet each. with Roadway 25 feet wide side Towing path Arches (vide Atlas Sheet No LII) Ghats are attached to the down Stream side of this bridge, and near the bridge is a 2nd Class Choki

9th Bridge at Dutpoora, on a similar design to that at

and the Roadway is only 18 feet wide

at Nanoon, but without Ghats, in near the Bridge is a 2nd Class Choki

10th " Bridge at Pooth, similar (excepting the Roadway which at this Bridge is 20ft in width) to that at Sutjoora, with a 2nd Class Choki attached.—

From the point below Sirdhuma at which the last section terminates, to Gullalabad and its neighborhood, which embraces the 20 miles of Canal course in advance of that before described, the Canal proceeds on the same bearing as before until it reaches the Village of Tewal Khas; at this point a series of Curves on radii of from 3 to 5 Miles commence, for the purpose of meeting the watershed of the country which henceforth takes a direction more to the East; these Curves continue to a point below Gullalabad near the Village of Raoli.— The Canal on the 20 Miles to which this description is confined, passes on its left, the Towns of Meerut, Begumabad, and Gullalabad, the former with its Military Cantonments being situated at a distance of 8 Miles from the nearest point of the alignement. On its right are Dholuri and Moradnuggur, the latter lying within a short distance of the Canal.— 80th to 100th Mile

The width of Country over which the Canal passes, measuring transversely across the Canal between the East Kalli Nudi and the

Hindun

Nindum River is at Tridhunna
15½ Miles; this increases in ad-
=vance, until at Dullalabad, the
above two Rivers are separated
by a width of 26 Miles; at
Tridhunna the Canal runs cen-
=trically between the above boundaries
being separated from the East Kalli
Nuddi by the Khodara Nulla
which at this point is a mere
shallow depression; as it advances
however, it keeps nearer to the
Nindum from which at one point
of its course opposite Dholuri,
it is separated by a distance
of only 4 Miles; the cause of
this close approximation to the
Nindum, chiefly arises from the
interposition on the East of the
Choiya Nulla, a tributary like
the Khodara before described, of
the East Kalli Nuddi. The Choiya
Nulla rises at a point about 3½
Miles to the East of the Canal
on the latitude of Meerut; it takes
a Southerly direction nearly paral-
=lel to that of the Canal and joins
the East Kalli Nuddi after running
through a course of 30 Miles at a
point about 9 Miles below the
Town of Rajpoor, between which
and the Canal, the Choiya Nulla
passes; its character is precisely
the same as that of the East Kalli
Nuddi: in the early part of its
course, an ill defined straggling
Nulla, running through land
ill cultivated on its edges, and
excepting in the rainy months
perfectly dry; in the latter part
and on its junction with the

River

River to which it is tributary, carry
=ing a sluggish stream through
a deep section, with a valley more
or less extended. All these Nullas
are of this character, from their
heads which generally receive
the drainage of extensive flats
of country, they proceed on their
course, becoming gradually
deeper and wider, until they
reach the main river to which
they are tributary. The direction
of the main line of Canal, there=
=fore, is in a great measure de=
=pendant on this Nulla, and
the low lands which lie contigu=
=ous to it.

The slope of the surface of
the country is about 35 feet, which
averages 1·75 feet per mile; in a
transverse direction the inclination
is towards the East, but in such
a small degree that it is hardly
perceptible, the line of Canal in
fact is distinctly on the high ridge
at the village of Sanni Khoord,
and it proceeds onwards to
Sullalabad on the same elevated
position. The country over which
the works are carried between
Tirhunna and Sullalabad
is on an average taken from
six measurements from the
Surveyors returns, 43 feet above
the bed of the Bindwa, and
32 feet above that of the East
Kalli Nuddi; the Choiya or
river which intervenes, having from
the neighborhood of Bhola (at
which point its heads are on a
level with the Country) obtained

a

a depression of 16 feet. Cross sections taken by myself in 1820, shewed that the land at Sanni Khoord was 45·925 feet above the bed of the Nindun River, and 3·33 feet above that of the Choiya, ~~which, at the point on which my rod was placed was about 2 miles from its head;~~ at a point 2 miles from its head; a cross section at Jullalabad proved that the bed of the Nindun was 47·54 feet, and that of the Choiya 24·64 feet below the country on which the line of Canal was to be carried; the Choiya, therefore, had in passing from the latitude of Sanni Khoord to that of Jullalabad ~~gained~~ accumulates a total fall of 21·31 feet ~~of depression~~ which, as the distance is 14 Miles, is equal to 1·52 feet per mile.

The country through which we are now passing is ~~of a~~ very highly cultivated ~~nature~~, a remark that may apply to the greater portion of that lying South of Khutowli. Between Sirdhumna and Jullalabad the Sandy and Bhoor tracts are more subdued than they have been previously; the Canal excavation is generally speaking carried through a good Subsoil, with ~~a sand formerly that~~ lying beneath it, ~~sand~~. With exception of 7100 feet in length of Channel opposite Moradnuggur where the excavation is shallow, the minimum depth being only 5·61 feet, the ~~depth~~ bed throughout is sufficient to hold the maximum supply of water, and on that portion where a deficiency of depth has led to heavy Embankments

=ments, these works are ~~of such a~~ so
=massive and ~~extensive nature~~ wide
that no danger from breakage,
nor evil from the percolation of
water need be at all anticipated.

At the village of Sannikhoord is a third Escape (No 3) connecting the Canal with the Nindum; this work has a waterway of 60 feet, divided into 10 Sluices of 6 feet each; its dimensions both in Masonry and capacity of Channel are precisely the same as those of ~~that described as~~ No 2 at the Site of Mahomed Abdoo's Canal, and the arrangements for the passage of the west Rajbaha, and the retrogression of bed levels are projected on the same design.

The distance from the Canal to the Nindum at the point where the Escape is built is equal to 5¾ Miles and the difference of level between the bed of the Canal and the bed of the River is ~~35·07~~ 38·06 ft

The maximum depth from the surface of the Country to that of the water in wells by observations during the month of March is on the 20 miles above described, equal to 37·91 feet, and the minimum 21·32 feet.

From the Pooth Bridge downwards the following works have been constructed.

1st Falls and Works at Bhola similar to those which have been before described, but with a waterway over the falls of 150 feet in width as at Sulaway; there is some deviation from the original

original design in the lining out of the Navigation Channel, arising from the village of Bhola interfering with the alignement, in other respects the works correspond in every way with those which have been before described

2nd No 3, or Jannikhoord Escape, similar in every respect to the works at No 2, or Mahomed Abois Escape Waterway 60 feet in 10 Sluices of 6 feet each.—

3rd Bridge at Jannikhoord similar in design to that at Pooth (Atlas Plate No LII) with a 2nd Class Choki attached to it.—

4th Bridge at Nugla with a 2nd Class Choki; both of them similar to that at Pooth.—

5th Bridge at Newarri similar to that at Pooth; but Roadway only 18 feet wide. with a 1st Class Choki attached

6th Bridge at Sounda similar to that at Pooth; but Roadway only 18 feet wide. with Ghats on the wings both on the up and down stream sides with a 2nd Class Choki attached

7th Bridge at Didoroli similar to that at Pooth; but with Roadway only 18 feet wide. with a 2nd Class Choki attached.—

8th Bridge at Moradnuggur similar in design to that at Pooth; but having a Roadway 25 feet wide and with Ghats on its down stream side corresponding in design with those which have been built at Khutoroli and Sidhumma (Atlas Plate LII).—To this bridge a 2nd Class Choki is attached

Ai

100th to 120th Mile

A further distance of 20 miles the first portion of which is in continuation of the curve which I have before described as commencing at Sewal Khas, takes us to the neighborhood of Sikundrabad, a Town situated in the Bolundshuhur District, the Curve terminates at a point near Dasna from whence up to the 120th Mile, the Canal pursues its course in an uninterrupted straight line. Its direction which from Sirdhuna to Jullalabad inclined rather to the West, or to the Hindun side of the Doab, on this Section takes an opposite course: from the point near Dholuri in fact where the Canal and the Hindun River approach to within ½ Miles of each other, the Canal takes an oblique direction across the Country towards the East Kalli Nudee, from which at a point a few Miles below Sikundrabad it is only two Miles distant. Throughout the whole of this line the Canal Tract has for its boundaries the Hindun on the West, and the Choiya, and latterly the East Kalli Nudee (after the junction of the Choiya with it) on the East. At a point almost directly at right angles with the line of Canal at Sikundrabad the Hindun joins the Jumna; and the low lands or Khadirs of these Two Rivers, which from Delhi and Ghazioodeenuggur downwards are united, extend over a surface varying from ½ to 13 Miles in width, and thereby very

considerably

considerably reduce the area of the high land in immediate con=
=nection with the Canal.-

The slope of the surface of the Country on the line over which the 20 miles from Dullalabad to Sikundrabad passes is 33·31 feet or 1·66 feet per mile; the width may be estimated on an average at 26 miles including the land cut off by the Choiya on the East, and the Khadir lands of the Rin=
=dun on the West; the surface is in a general point of view flat, or broken by irregularities un=
=worthy of any particular con=
=sideration, the direction of the Canal, however is high, and on a cross section from the Rindun viâ Ghazioodeennuggur, Dasna, Galund, Kabul, and Kumalpoor to the Choiya Nulla it crosses at ~~the~~ highest point of profile near the village of Galund: that point being elevated 40·7 feet above the Rindun and 15·58 feet above the Choiya.-

It was on this line, and from a point in the Canal near Moradnuggur or Dullalabad, that in my first report written in 1840, I pointed out the probable advantage that might be derived from carrying a line of navigable Canal to the Rindun River - with a view to ascertain the capabilities of the Rindun, I had measurements (Transverse) in width and depth taken at every thousand feet in length from the Bridge which crosses the River at Ghazioode=
=eennuggur to ~~the~~ junction

~~of~~

with the Jumna
~~of the River~~ near the village of
Dunkoor; these measurements
which were taken in the month
of April shewed that with the
exception of one part of the course
of the River near the village of
Gojer, where the depth of water
varied from 1½ to 1·3 feet, the
average depth might be estimated
at between 3 and 4 feet, on a
width varying from 70 to 50 feet
The total distance between the
Ghaziooddeennuggur bridge on
the Hindun, and the junction
of that River with the main
Jumna, was 30½ Miles, the course
being exceedingly tortuous, and
on its whole length passing through
~~the~~ Khadir (and
(appendix G)
=ment. A Tabulated State
will be found in the volume of
Tables attached to this paper.—
With Lockage of 35 feet, or thereabouts,
a line of still water might be
carried from the Canal to a point
on the Hindun below the bridge
at Ghuzioodeennuggur, by which
means a direct line of water com-
=munication would be obtained
between the Ganges at Hurdwar
and the Jumna. ~~Observe~~ In
the report in which this subject
was ~~particularly~~ alluded to, it was remarked that
the uses of such a Canal "in the
"mere introduction of Timber and
"forest produce, would be of infinite
"importance, as enabling the
"Delhi and Agra markets to be
"supplied direct from the Forests
"which lie in the vicinity of the
"Ganges at its debouche from the
"mountains"

"mountains"

The Country is throughout richly cultivated, and the Soil of a better description than it was in the Bhoor or Sandy Districts. Sand however is still an attend=ant on all excavations exceeding a few feet in depth, and the occur=rence of Spring water at shallow levels was in some cases a matter of great inconvenience, espcially at the Falls and Locks, where it was considered advisable to lay the foundations at a depth below Spring water level. Through=out the whole of the distance however, extending from Fullalabad to Sikundrabad the depth of Excavation is sufficient to carry the full Canal Supply

At, or near, the 110th mile and near the village of Duhuna the Bolundshuhur Branch leaves the Canal on its right bank; this branch is intended for the irrigation of the different pur=-gunnas that lie on the edge of the Gumna Khadir, Dewar, Dunkoor, Tuppul &c: it crosses the low lands in which the heads of the Putwai Nulla are situa=-ted to the Eastward of the village of Kot, and from thence pro=-ceeds onwards between that Nulla and the Karoon River, another line of drainage which rises in the neighbourhood of Parpuh a village which is situated on the left of the Main Canal. The Works which are attached to the head of this

Branch

Branch are (with the exception of the reduced widths to waterway adapted to the particular position in which they are situated, and to the calculated discharge of water necessary for the Branch supply) similar in detail and in design to the Futtigurh Branch Head works before described; the Regulator over the Canal at this point has 8 bays of 20 feet each, and that of the Branch has a waterway of 50 feet, divided into one centrical bay of 20 feet, and 2 side bays of 15 feet in width each. —

The depth of Spring water from the surface of the earth is throughout the above line of 20 Miles much the same as it was in the Khutowli neighborhood, its Maximum on a number of observations taken at different villages during the month of February being 40·65 feet, and the Minimum 22·65 feet, measuring from the surface of the Earth to the surface of the well water. —

From the Moradnuggur Bridge, ~~before described~~, the following Works have been constructed

1st Bridge at Noorpoor, similar to those before described (vide atlas Plate LII) with a 2nd class Choki attached

2nd Falls and Works at Dasna similar in every respect to those at Sulawar and Bhola and with the same width of waterway. —

3rd

3rd. Bridge at Peepulkheri.
3 arches of 45 feet each - 20 ft Roadway with Ghats on both the up and down stream sides - and a 2nd Class Choki attached

4th. Bridge at Raoli, similar to that at Peepulkheri, but without Ghats a 2nd Class Choki attached.

5th. Bolundshuhur Branch Headworks.

6th. Bridge at Nidhowli, with 3 Bays of 45 feet each, with Ghats and Rajbuha and Inlet Heads (vide Atlas Plate L) with a 2nd Class Choki.

7th. Bridge at Dancha, similar in every respect to that at Nidhowli, with 2nd Class Choki attached.

8th. Bridge at Seesoopoor of the same description and design as that at Nidhowli with a 1st Class Choki attached.

The use of Kunkur which had been confined either to building in beton or concrete; or to filling in at the tails and other points near Bridges and Falls where protection was required; became on this line of works the staple material for building not only foundations but superstructure The works from the Bolundshuhur Branch Head downwards, with the exception of bridge Arches, have been built almost entirely with Kunkur, which is procurable from Quaries in the neighborhood; the Material although variable in compactness and requiring

in

in use some circumspection, is undoubtedly one of a very superior quality; and perhaps one of its greatest recommendations was its extraordinary abundance, & which enabled the Executive Officer to carry on without interruption the whole of the bridges and works at a period when Bricks were literally not procurable and when, had it not been for the occurrence of Kunkur Quarries, the failures in the Brick manufactories would most undoubtedly have necessitated an entire stoppage to the works. The subject of building in its details, however, will be entered upon hereafter; the fact of Kunkur being used is merely alluded to here, from its being a remarkable feature in the progress of the works, and in the ~~production~~ resources of the country.

The next 20 miles brings us to the neighborhood of Khooja, a large Town situated on the Grand Trunk Road, and at a distance of 2 miles on the right of the Canal: at this point we are 140 Miles from the head at Myapoor. 120 lbs to 140 lbs Mile

The Kuroon River to which I have before adverted as rising in the neighborhood of Parsuli, passes off in a Southerly direction increasing in departure from the East Kalli Nuddi as it advances in its course; in its & natural features it resembles in

all

all respects the Choorja as before described, and after a course of 90 miles joins the Jumna near the Village of Thahdurra in the Agra District, at a point just below the Town of Agra.— The Kuroon River passes to the East of Sikundra, and to the west of the Town of Khoorja at a distance of 1½ miles, and proceeds onwards by the Towns of Khyr, Russungunh, Mudsan and Saidabad to its junction with the ~~great River~~ Jamna. —

The line of canal, therefore, in its passage through this portion of the Bolundshuhur District after crossing the low land in which the heads of the Kuroon are situated; runs between that River and the East Kalli Nuddi; at their widest points of separation they are only 7½ miles distant from each other, whilst immediately opposite the Town of Bolundshuhur which is built on the high land overlooking the Valley or Khadir of the East Kalli Nuddi, the width does not exceed 1½ miles. The Canal alignement passes within 1/4 Mile of the Town of Bolundshuhur, and throughout the whole of the 20 miles which I am now describing, runs parallel to, and at a distance of from 5 to 1½ Miles from the East Kalli Nuddi. — In the early part of its course its direction is in prolongation of the straight line from the Bolundshuhur Branch Head, but at the 12.7th and 13.1st Miles

and 131st
Miles, there are curves on a radius
of 15414 & 21300 feet, bringing the line
to bear on a westerly direction,
and at the 139½ Mile a curve
of the former dimensions to
give it a direction towards
the East; these Curves are adapted
to the general direction of the
high land and the water shed,
as well as to open country un-
-connected with sites of houses
or villages. The low land which
lies at the head of the Kunoon,
and which is intersected by the
Canal in the vicinity of the
120th Mile, has not been considered
of sufficient importance to call
for additional works, nor from
the experience that we have
had since the Canal has been
dug and its embankments have
been made, does there appear to
be any necessity for them.

The slope of the surface of
the country on its longitudinal
section is 28·5 feet or 1·42 feet
per Mile, and transversely it
inclines from the East Kalli
Nuddi towards the Kunoon,
or from East to West. The country
is richly cultivated throughout,
although intersected by Bhoor
or sand ridges in the neighbor-
-hood of Khooja. The Canal Ex-
-cavation is through a tolerably
good soil, with the exception of
those portions of it which are
connected with the Sand; the
soil below the bed is of a light
and not very satisfactory des-
-cription: the depth of excavated
Channel, however, is sufficient

for

for the high water supply, and in this respect is well adapted to the purposes for which it is intended

A Cross section taken by me from the East Kalli Nuddi at Bolundshuhur to the Kuroon River, shewed that the Surface of the Country on which the Canal takes its course is 22·33 feet above the bed of the former and 6 feet above the bed of the latter.- A similar section taken transverse-ly across the Country at the Town of Khooja shewed that the East Kalli Nuddi was 21·83 feet, and the Kuroon 10·5 feet be-low that of the Canal line;. the distance longitudinally between these 2 sections being equal to 11 Miles.-

The only works on this line are bridges, which have been built on the same design as those before described in the former section from the Bolundshuhur Head downwards; at the crossing (at Wullipoora) of the high road between Allygurh and Bolundshuhur, the Ghats which are universally attached to the bridges, are more extended in length, and greater conveniences are provided for approaching the water for the purposes of bathing, but in other respects the appointed Rajbaha heads, Inlet, Towing path passages &c are precisely similar.. The following is an enumeration of the Bridges from the 120th to the

the 140th Mile.-

1st Bridge at Tunorta with Ghats, Rajbaha and Inlet Heads similar to that at Nidhowli (Atlas Plate L) with a 2nd Class Choki attached

2nd Bridge at Pukkana similar in every respect to that at Nidhowli. with a 2nd Class Choki attached

3rd Bridge at Dumkoura 135 feet waterway in 3 Bays of 45 feet each. with Ghats on the down stream side (Atlas Plate L) and 1st Class Choki attached

4th Bridge at Urrowli with Ghats, Rajbaha and Inlet Heads (Atlas, Plate L) 135 feet waterway in 3 Bays of 45 feet each. Roadway 25 feet broad a 2nd Class Choki is attached to this work..

5th Bridge at Willipoora with Ghats, Rajbaha and Inlet Heads (Atlas Plate L) Waterway and Roadway are the same as at Urrowli. with a second class Choki attached

6th Bridge at Mamu~~n~~ 12 similar in every respect to that at Nidhowli; with a 2nd Class Choki attached.-

7th Bridge at Uchuhja similar to that at Dumkoura with 2nd Class Choki attached

At the Urrowli Bridge the high Road between Bolundshuhur and Delhi, and at the Willipoora Bridge the Grand Trunk Road

in

in its route from Khoorja to Bolundshuhur, cross the Canal; at both these points increased width to the Bridge Roadways has been given, and at the latter one, additional length of bathing Ghat also.— Throughout all this line of works Kunkur has been the staple material for building purposes.—

The depth of wells on the usual recorded measurement viz^{o}: from the surface of the earth to the surface of the water, is on a maximum 36 feet, on a minimum 15 feet throughout this section.—

112 th to 160 th Mile

From the 112 th to the 160 th Mile the direction of the Canal continues on a straight line, maintaining its course in proximity to the East Kalli Nuddi which opposite to the 160 th Mile takes a considerable curve to the Eastward, regaining its position with regard to the Canal alignement a few miles South. The width between the two Rivers (East Kalli Nuddi and Kurroon) which in the latitude of Khoorja is about 11 is at this lower point 2½ Miles; the Country is well cultivated throughout, and its slope longitudinally is 27·73 or 1·38 feet per Mile; transversely the slope of the Country is from East to West, but the Canal runs on a high level, and keeps well to the Watershed:. Opposite the Village of Gungowli the line comes in contact with sand

ridges

ridges through which it is ~~made~~ carried;
in other respects the soil is good,
although in excavation, sand
and a lighter species of soil
shews ~~itself~~ themselves in increasing abund-
=ance below the levels of the Canal
bed.- On this line the Channel
is somewhat shallower than the
high water mark of the Canal
calls for, the deficiency has been
made up by embankments, of
such a nature as to preclude
any accident or lead to incon-
=venience to the country; the
earth for this purpose has been
procured from the surface on
the outside of the canal bound-
=aries, and necessary measures
have been taken to secure these
excavated areas from deposits of
water

~~At the point~~ Where the Canal
runs on the 160th Mile, the surface
of the country is 15·62 feet above
the bed of the Kurroon and 25·33 feet
above that of the Cast Kalli Nuddi

At the 163½ Mile, at the
village of Moonda Khera, Nos
Escape is situated; this work
which in waterway is equal to
60 feet in 10 Sluices of 6 feet each
is attached to the upstream side
of the Moonda Khera Bridge
with its head well protected by
masonry revetments constructed
in the steps form as that most
convenient for the purposes of
approach to the water. This Escape
is connected ~~in a manner with~~ with the
Bridge by long lines of steps
laid out in the form of an
Ogee Curve, and forms with the
different Inlets and Rajbaha, or
main

Main water course heads, a very complete and very handsome mass of building; its situation is directly opposite and to the East of the Town of Khoorja for the convenience of the population of which these extensive Ghats were especially constructed. At this point and intermediate between the Escape and the Bridge is a 1st Class Choki building, the site being intended as one of the main stations on the line of Canal. -

The Escape Channel which is excavated on a width of 50 + feet, is cut out to the valley of the East Kalli Nudi; the dif-=ference between the Escape flooring and the bed of the River being 16·74 feet on a distance of 9500 feet Here again, as was explained in the Escape Channels towards the West Kalli Nudi, the ar-=rangements for the passage of the main line of Rajbaha will be designed in connection with a bridge of cross commu-=nication and a descent in + masonry; further operations with regard to retrogression of levels from the bed of the East Kalli Nudi being postponed until the practical effects of wear and tear by retrogression have exhibited themselves: in preparation however for this circumstance, material has been collected, so that the means for counteracting the evils will be at a moments notice avail-=able

=able.-

At the 149th Mile the Pulra Falls deliver the whole body of the Canal water on a level 5 feet lower than that on which it has been running; this work consists of 5 bays of 20 feet each giving a clear waterway of 100 feet. The general design of the work being the same as that which has been before described.- The works at the head of the Navi=gable Channel locks, mills, Rajbah Heads &c. are all built on the same design (vide Atlas Plate xxx)

Three Miles below the Pulra Falls, and close to the 152nd Mile Stone, the Koel Branch leaves the Canal on its right. The works at the head of this Branch are on the same design as those at the Bolundshuhur branch head be=fore described; the Regulating Bridge over the Canal having a waterway of 120 feet divided into 6 Openings of 20 feet each, and that across the head of the Branch having 50 feet waterway viz^t: a centre bay of 20 feet, with 2 side bays of 15 feet in width each, the works attached, with the Choki of 1st class dimensions are the same as before described.-

The capacity of Channel for the Koel Branch is the same as that for the Bolundshuhur, the head discharge being es=timated at 520 Cubic feet per second

The

The object of placing the head in the position in which it is situated, is to secure a line of channel as free as circumstances will permit, for the low lands which lie to the South east of Somna, in the neighborhood of the Fort of Alleguh and the Town of Koel; these low lands or flats which are very extensive are connected with a good deal of the downward drainage of the Country; the Rinde and Seyngoor, the former on the east, and the latter on the west, derive their head supplies from this neighborhood: the Seyngoor however, or that River which is most directly connected with the Koel drainage, and which at all periods of the rainy months acts as the Sluice from this particular part of the Country, is the line whose heads it was the main object to turn, and this will be very tolerably effected from the point which has been determined on. The fall or declivity of the surface of the country corresponding with that of the lower levels which the Canal has gained by its descent over the Pulna Falls.

The Koel Branch will irrigate that portion of the County which lies between the Kurroon and the Seyngoor Rivers, its direction has not been accurately determined, but the Transverse Sections of the Country which were obtained in the Original Surveys define the line with some degree of accuracy, as bearing to the East and close by the

the Town of Somna, to the west of Koel, and onwards to the richly cultivated districts in the neighborhood of Rattras and Sasni

In describing the Choriya and Kunoon ~~Rivers~~, I have in fact explained the character both in its rise and progress of the Seyngoor River, which, as I have before mentioned, acts as the left or Eastern boundary of the Koel Branch; this River which in the early part of its course ~~runs in~~ takes a Southerly direction, continues onwards inclining to the East; it runs through 190 miles of Country, passing through the Districts of Alliguns, Etawah Mynpoorie and Cawnpoor, and joins the Jumna River in the latter District; this junction is effected near the Town of Moosanuggur at a point almost centrically situated between the two Stations of Kalpi and Bumeerpoor, which lie on the opposite or right side of the River. The increasing width and depth of section that I have noted as characteristic of the Rivers in the Doab, lead in consequence of the great length of the Seyngoor to its becoming a very formidable River running through deep and Raviny ground on the latter part of its course and on its approach to the Jumna. It is a line which is very intimately connected with the Ganges Canal works, as providing a boundary to the tract upon which the Etawa Branch runs,

and

and in this point of view is one well deserving of attention when considering the design which has been adopted in laying out the main lines of Irrigation.—

The works on this section, or from the Uchuly a bridge downwards are as follows.—

1st Moondukhera Works, consisting of a Bridge of 3 Bays of 45 feet each, Rajbaha Heads, Inlets, Ghats and Escape No 4 into the East Kalli Nuddi, with a first Class Choki attached (atlas Plate XXXVIII)

2nd Bridge at Tuhunda with a water way of 3 Bays of 45 feet each, with Rajbaha Heads, Inlets and Shuts; with a 2nd Class Choki attached

3rd Pulra Falls and works, the Falls having a waterway of 100 feet in width divided into 5 bays of 20 feet each - Head to Navigable Channel, Locks and other works precisely similar to those before described (Atlas Plate XL)

4th Koil Branch Head works similar to those at the Bolundshuhur Branch Head. the water way of the Branch Regulator being 50, and that of the Main Canal Regulator 120 feet in width. To these works a 1st Class Choki is attached.—

5th Bridge at Daoopoor with a waterway of 3 bays of 40 feet each; Rajbaha and Inlet Heads, Ghats and a 2nd Class Choki attached.—

6th

6th Bridge at Birowli, similar to that at Davoopoor, with a 2nd Class Choki attached.—

7th Bridge at Dubthulla, similar to that at Davoopoor, with a 2nd Class Choki attached.—

The depth of wells, or the difference of level between the surface of the water in them, and the surface of the country is on a maximum feet, and on a minimum feet.—

In advance of the 160½ Mile the alignement continues direct to the neighborhood of the village of Simra at which there is a curve on a radius of 20000 feet which brings the Canal on the direct bearing of the Head works of the Etawa and Cawnpoor ~~Branches~~ Terminal lines, and of the villages of Nanoon and Rajoopoor between which these Head works are situated; at this point which is 180 or 180 4/5 Miles from the Regulator of the Canal Head at Mryapoor, the Main Trunk of the Ganges Canal terminates: the Spot is marked by a Solitary Tarri or Fan Palm tree (Borassus flabelliformis) the first of its race that shews itself on the works, and with the exception of a few plants scattered sparingly in the Saharunpoor, and in the Districts between it and Nanoon almost the first Specimen of this Species of Palm which shews itself in these Northern latitudes

The Slope longitudinally of the surface of the Country from the 160½ Mile is 26·86 feet

giving

160th to 180½ Mile

59

giving an average per mile of 1·3½ feet, its transverse slope tends towards the Westward from the East Kalli Nuddi to the Kuroor, and ultimately, as the Canal proceeds onwards, to the Beads of the Seyngoor River. The Canal alignement is in fact kept as near as possible to the East Kalli Nuddi, so that it may avoid the low tracts in which the Seyngoor drainage commences, and in the neighborhood of Kundooguny the Canal, which passes between that Town and the East Kalli Nuddi, approaches to within 1 3/4 Miles of the latter. in defiance however of this close approximation to the above River, the depth of Canal excavation is on a considerable length insufficient for the high water supply; Embankments have been made to meet the required height from earth excavated from the outside of the Boundaries, ~~and the means that have been taken~~ the consolidation of ~~these Embankments~~ the high Embankments, together with the magnitude of their proportions, will secure the Country from any liability to accident; ~~and~~ the measures which have been taken to secure efficient Inlets also will, it is to be hoped, relieve the neighborhood from ~~the~~ inundation. There was so much Earth required for these lines of Embankment, that the usual method of taking a Superficial foot in depth over large areas was utterly impracticable, from the distance to which Earth would have

have to be carried; I therefore deter-
=mined on the excavation of a
series of Tanks at fixed distances
from the Canal boundaries, as
well as from each other, of dimen-
=sions in squares or oblongs adapt-
=ed to the Cubic Contents of earth
required for the Canal works: it
struck me that compactly formed
and deep tanks or Reservoirs might
hereafter be of great use in catch
=ing supplies of drainage water,
and of adding their Quota to the
irrigation of the fields in the neigh
=borhood; the depth to which
these Reservoirs are dug will pre-
=vent the accumulation of water
reeds, and the rank vegetation
that usually attends Shallow
pools. At any rate, the necessity
should the Speculations on their
use as Machines for irrigation
hereafter be accomplished (or not) of
keeping them clean and free
from Malarious appendages
may be considered a duty at-
=tendant upon the Supervision
of the works.

The width of country be-
=tween the East Kalli Nuddi
and the Kunoon at the 160th
Mile of the course of the Canal
is 24 Miles, and it continues
very nearly on this width to the
180th Mile, or to the Branch heads
at Nanoon; here, however, the
intervention of the Seyngoor
River which has at this point
of its course arrived at a well
defined Section, reduces the width
to 10 Miles over which the Canal
runs intermediately, the works

being

being situated exactly on the highest ground, and midway between the two Rivers.

At the point where the Canal passes the Town of Burdwaguy, the Surface of the Country is 22:33 feet above the bed of the East Kalli Nuddi, and 18·84 feet above that of the Kunoor, at points at right angles to the Canal Channel.

The country throughout the whole of these 20 miles is well cultivated, excepting in the plains in the immediate neighborhood of the heads of the Seyngoor; there is a good deal of Irrigation from wells, the maximum depth of water from the Surface of the Earth being 49 feet and the minimum 16 feet

Near the village of Simra, and at the 163rd Mile of the course of the Canal, the water is let down to the lower levels by another set of Falls similar in every respect to those before described at Pulra; this abrupt descent is, as in the case of the Pulra one, equal to 5 feet in perpendicular height, and it completes the great step of Country which is met with ~~takes place~~ on the approach to the heads of the Seyngoor and Rinde which flow towards the right to the Jumna, and to the Eesun which passes off to the Ganges on the left: The Navigable cut with its arrangements for the departure of vessels from the main line, its locks, Mills, and Rajbuha

Read

Heads are precisely similar in de-
=sign to those figured in the Atlas
Plate xxx

Near the village of Kasimpoor which is situated about 3 miles below the Sirra Falls, an Escapr, No 5, into the East Kalli Nuddi, similar in dimensions to that at Moonda Khera, viz: 60 feet waterway divided into ten sluices of 6 feet each, is built in connection with the Bridge, on the same design, and with an excavated channel of 50 feet in width, precisely as has been described at the Moonda Khera works the distance between the canal at the Kasimpoor Escapr and the East Kalli Nuddi is ~~1393~~ 20577 feet and the total fall between the Escapr flooring and the bed of the River is ~~4·3 feet~~ 21·35 feet
The plan which has been before described for getting over the diffi=
=culties of excess of slope in the bed of these Escapr Channels will be practised at the Kasimpoor works: and the method of passing the Eastern Rajbaha across the Escapr Channel will be in every respect similar to that which has been adopted before.—

The Head works of the Etawah and Cawnpoor ~~Branches~~ Terminal Lines, are in design like those at the Branch Heads before described; the Main Trunk Channel on its approach to the Heads, however, bears on a line which bisects, or which divides into two equal parts the angle of departure of the Two Branches. this angle is equal to 43 degrees, and the main line meets it on an angle of 158½ degrees — The design

design of this particular lining out of the works is, that the Current of the main line shall meet the branches on its right and left under precisely similar circumstances, so that (capacity of channel, slope of bed and) as far as direction are concerned the supply of each branch shall correspond, this correspondence is further maintained by the Regulating Bridges over the Head of each being of the same dimensions, viz^{t} of 100 feet waterway divided into 5 Bays of 20 feet each - The supply of each branch, therefore, although laid down as equal, can be regulated in any way that it is desired, through the medium of the Regulating apparatus; in case where such is required in fact, one or other of the branches can be laid entirely dry; any surplus water being passed off at the Escapes at Kasimpoor or Moonda Khera -

The Grand Trunk Road between Cawnpoor and Alligunh crosses the line of Canal over the Regulators at these Heads - The position is one of great importance, and as a main Canal post, has a 1st Class Chokí attached to it -

The works on this section or from the Bridge at Dubthulla downwards may be thus enumerated.

1st Falls and works at Simia, similar in every respect to those at Pubra, (vide Atlas plate XL)

2nd Kasimpoor works, consisting of

of a Bridge of 3 bays of 40 feet each in waterway, Rajbaha and Inlet Heads, Ghats and Escape No 5 into the Kasthalli nudi, with a 1st Class Choki attached.-

3rd Bridge at Barota with a waterway of 3 Bays of 40 feet each; with Rajbaha and Inlet Heads, Ghats, and a 2nd Class Choki attached.-

4th Bridge at Machoor similar to that at Barota with a 2nd class Choki attached

5th Bridge at Chungeri similar to that at Barota with a 2nd class Choki attached

6th Bridge at Sheka, similar to that at Barota, with a 2nd class Choki attached

7th Nanoor Headworks similar to those before described at the heads of the other 4 branches, but with the Regulating Bridges having a waterway of 100 feet each, divided into 5 bays of 20 feet each - a 1st class Choki being attached to the works.-

As noted in the works throughout the Bolundshuhur District, the staple material for building has been Kunkur, the use of Bricks being confined to Arches and to those works where Kunkur was not procurable.

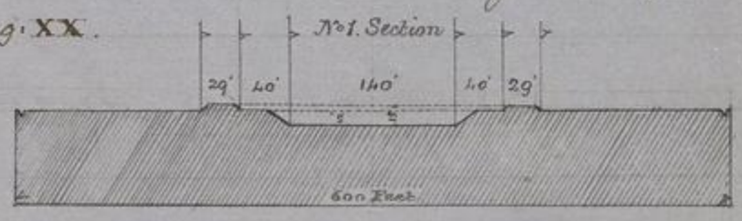
The works at Nanoor which are situated at the down stream extremity of the main canal ~~line~~, are the terminal point of the Section included

between

between the Entrance upon the high land at Roorkee, and the Fork at which the Etawah and Cawnpoor Branches separate. I have given in the above detail as full a description as possible of the profile and extent of Country over which the Canal passes, and it will be observed from this detail that the arrangements which have been made for the different subordinate lines or branches provide the means for Irigation on the whole length and breadth of the Country from the Ranges on the East to the Nimdun and Jumna on the West, and that the extraordinary declivity of profile which takes place on the early part of its course, enables us to gain the most efficient head supply for all the side lines, whether these are Canals for the use of lands situated at great distances from the Main Channel, or whether they are Rajbuhas or main water courses for the Irigation of lands lying within a moderate distance.

The Capacity of the Channel from Roorkee to the Head of the Futtiguh branch or to the 58th Mile of the course of the main Canal, has not been increased from the dimensions laid down in my Estimate of 1815; the minimum section being as follows:

Diag. XX.



That is to say, the height of the top

top of the bank from the Canal bed is 15 feet, and that of the berm from the Canal bed is 12 feet; the latter is a constant quan-tity, and although it is exceeded in many places where the depth of excavation is very great, the depth of 12 feet for the trapezoidal portion which is intended for the retention of the Canal water is always maintained; the height and width of the Embankments ~~vaies~~ varies with the amount of earth excavated from the Channel, but the earth is always spread out, so as to form an even Esplanade. and it is only at those parts of the Canal, South of Togulpoor for instance, where the Depression of the Surface of the Country led to Shallow digging, and consequently to an artificial formation of berms and Embankments that the min-imum section is practically exhibited. —

The width of Waterway of the Falls and Bridges, however, has been increased from 150 to 200 feet, and the latter by the removal of the Solid towing path which was projected into the stream, from 150 to 165 feet. The Canals Channel may be considered as far as its bed is concerned to consist entirely of Sand, and a consequent wear and tear of slopes and sides, leading to a gradual extension in width to the earthen Channel may be anticipated

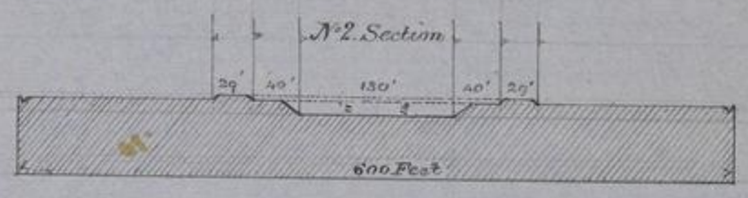
It will be observed by referring

to

to Diagram XVII. page 265, that the estimated maximum discharge at Roorkee is equal to 6750 Cubic feet pr. second, and that this supply by the abstraction of 330 Cubic feet pr. second for the Rajbaha heads at the Assofnuggur Muhmoodpoor, Bela and Sobli falls to each of which 1½ Cubic feet pr. second has been allowed, and of 1210 Cubic feet pr. second for the supply of the Futtiguh branch; is diminished at the head of the Canal Regulator at that point to 5180 Cubic feet pr. second

The Regulator across the Main Canal at the Futtiguh Branch head has, as has been before stated a water way of 180 feet in 9 bays of 20 feet each — From the Futtiguh Branch head, the section of the Canal is reduced to the following dimensions

Diag: XXI.



and this ~~dimension~~ is continued ~~consecutively~~ unchanged to the Khutowli, or ~~to the~~ No 1 Escape into the West Kalli Nudee, in supercession of the gradual diminution in width to 121 feet as it was ~~planned~~ designed in the Estimate of 1815. — The same remark applies here, as ~~it does~~ in all cases where a minimum section is given, viz^t: that much as the dimensions may be extended they are never reduced below the figures above noted, and the

three

three dimensions of 130-40-40, or the breadth of the Rectangle, and the distances between that rectangle and the foot of the Embankment slope ~~is~~ on each side are in all cases a constant quantity. ~~On~~ Ties waterway of posts this line the width of Bridges and Falls has been retained at the larger dimensions above specified, and bridges with side passages constructed on the flanks, and in prolongation of the towing path or the berm have been arranged for the convenience of traffic, as well as for ~~that~~ the extension of the bridge waterway

From the Khutowli Escape or from the 62nd to the 105th Mile, the section of the Canal is precisely the same as that above ~~prefixed~~ excepting only that ~~being~~ the width of rectangle is reduced from 130 to 120 feet; from the 105th to the 110th Mile, or to the head of the Bolundshuhur Branch, the width of rectangle is still further reduced to 110 feet; the section otherwise remaining the same, and the height of berm above the Canal bed being never less than 11 feet. - The Canal at the Bolundshuhur Head Regulator. ~~Canal~~ has to carry a supply equal to 4330 Cubic feet pr Second; the abstraction of water between that point and the Futtiguh Branch being equal to 3300 Cubic feet pr Second for the supply of the Rajbuha heads, and 320 Cubic feet pr Second for that of the Bolundshuhur branch. I may here remark that from Roorkee to this

point

point, or to the head of the Bolundshuhur Branch, the water for the purposes of Irrigation is taken from heads situated immediately above the Masonry Falls; of these heads Eight are on the right and Eight are on the left of the Canal; the supply of water allowed for these 16 Heads is equal to that calculated (vide Tables) for 82½ Miles at 8 Cubic feet per Mile: the upper 27½ Miles measuring from Mysapoor down-wards, having, for reasons be-fore Stated, been excluded from the Irrigating Districts:- Each of these 16 Heads, therefore, has a supply per Second equal to 41¼ Cubic feet, delivered from the Canal under the most advantageous circumstances of command over the Country, and of facility for securing a regular supply.- I consider that the means are so ample on this line for extending Irrigation, that there will be nothing to prevent the passage of the west Kalli, and the introduction of water courses on the Surface of the Country above the junction of that River and the Hindun: the Bridges and ramps of approach to the bridges on the west Kalli Nuddi may be the means of facilitating this object, but there can be no doubt that Aqueducts built Spe-cifically for the purpose, would lead to returns sufficiently remu-nerative.. The Station of Sapoor and the Stud lands which are separated from the line of Canal by the Chooja Nuddi will be

reached

reached with probably greater fa-
=cility by turning the heads of
the Kuddi itself; but I believe
that there is no intersecting River
on this tract of the country, with
the exception of the great boundary
lines of the Jumna and Ganges,
that ought to be looked upon as
offering the slightest impediment
to the passage of a Rajbaha:
with certain restrictions, depth of
section in a River or Ravine to
be crossed, is a positive advantage;
~~it is over those shallow tracts which~~
~~offer no depth of section at all,~~
~~and where it is absolutely necessary~~
~~to provide a sub passage, so that~~
~~the natural flow of the Country~~
~~drainage may not be interrupted,~~
~~that the point of intersection of~~
~~a line of Rajbaha, with its atten-~~
~~-dant embankments, is so often a~~
~~matter of anxiety and trouble~~

anxiety & trouble arise only in crossing those shallow tracts that give no depth of section at all, & thus render subpassages necessary to prevent interference with the natural drainage; in such localities lines of Rajbahas with their attendant embankments are often sources of expense & care

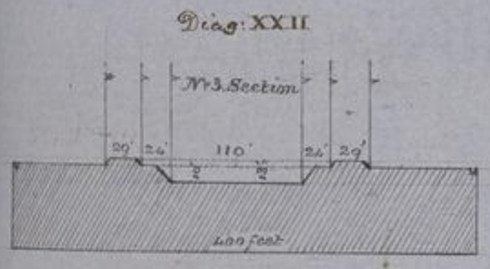
The water way of the Bridges
continue on the dimensions above
specified as far South as Sridhuma,
below which it is diminished to
150 feet in 3 Arches of 50 feet each.
below the Dasna Falls, this water
way is again reduced to 135 feet
in 3 Water ways of 45 feet each.
To meet the decrease of supply
and the diminished capacity
required, the Falls from Talawan
downwards are reduced to 150
feet in width of waterway.

The waterway of the Regulator
on the Canal which is situated
at and immediately below the
Bolundshuhur Road is, as I have
before mentioned equal to 160 feet in width
in

in 8 Openings of 20 feet each; the advantages of giving capa=cious Waterway in manageable openings at these Regulators are great, as it relieves the Channel from the wear and tear which would otherwise attend upon the working of the Shutters under a contracted Opening

From the 110th to the 114th Mile, the capacity of the Channel of the Canal is ~~continued~~ in width ~~on the same dimension~~ as described from the 105th Mile downwards, the difference between the berm and bed level being reduced from 11 to 10 feet it having been an object in this part of the course of the Canal to reduce the maximum depth of the water to 8 feet; the Section on this line is thus, →

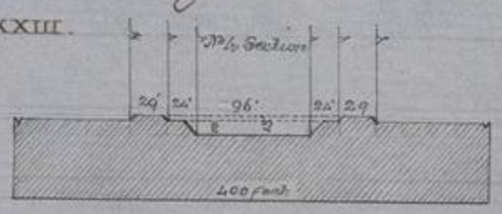
Diag: XXII



From the 114th mile or from the downstream side of the Suhenda Bridge to the 180th Mile, or to the Nanoon Regulators at the end of the Main line of Canal, the width of the rectangle is gradually reduced to 80 feet, by a reduction averaging 10 inches per Mile; The depth of trapezoidal Channel being maintained in all cases at 10 feet, so that there may be a clear 2 feet above the high water mark

At the Koel Branch Head the width of the Canal Channel is represented by the following section

Diag: XXIII.

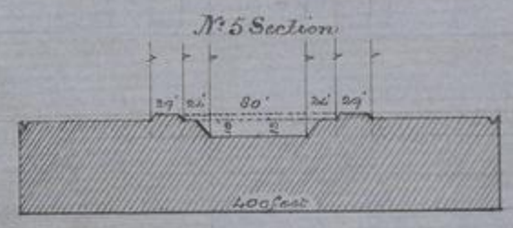


the

the discharge at that point being equal to 3530 cubic feet per second the Regulator over the Canal having a waterway of 120 feet in width in 6 openings of 20 feet each.

On the Channel reaching Nanoon, and immediately above the separation of the Two branches, its capacity is shewn by the following section

Diag: XXIV.



the Theoretical discharge on the arrival of the water at that place being equal to 3250 Cubic feet per second. —

I may remark that from the 110th Mile downwards the regularity of the berm at a height of 10 feet above the Canal bed has been maintained with great uniformity: the reason why the same regularity was not carried out in the Channel above this point was from the extraordinary ~~diversions in~~ depth of digging at parts where the Channel came in contact with the Bhoor land and the Sand hills, and the ~~consequent~~ great expense that would, in consequence have attended a reduction of the berm to one uniform level; at this period of our operations and with so much experience to guide us, I am not sure that it would not have been better, as it certainly would have ~~added to the~~ improved the look of the work

R, 241 : V.ii

work, had the berms been constructed on a level parallel with that of the Canal bed; in all cases however, they have been sloped off on long lines so as to render the irregularities as little apparent as possible, and in no case have they been made less in height than that designed, and as shewn in the minimum sections figured in the above diagrams.—

The width of waterway of the bridges from the 110th to the 180th Mile has been maintained on two uniform dimensions, viz^{s}. of 135 and 120 feet, the former having 3 bays of 45 feet each, and the latter 3 bays of 40 feet each. My object in keeping to these two sizes was to give the greatest pos=sible relief to the water in its passage through the bridges, and to simplify the construction, by which both time and expenditure were saved; the design of these bridges is the same as those before described with towing path arches in prolongation of the towing path of the Berm (vide Atlas Plate L)*

With the exception of the Dumkoura and Uchuly a Bridges, where the application of outlets for irrigation did not ap=pear to be desirable every bridge from the Bolundshuhur Head downwards, has 2 Rajbuha heads attached to it, One on each side of the Canal (vide Atlas Plate L) the Channels of these heads are made ten feet wide, for the purpose of giving full scope either for the Escape

* Where the Text as follows:.
"The Pulra and Simra Falls have a waterway of 100 feet in width, and are so well protected that the water will have no doubt pass over them with as little obstruction as could be desired.—

escape of water, or for the fixing of Modules or other apparatus that may be at any time designed for the purpose of regulating the discharge: the width and height of these openings as they have been now built will, I hope, place it ~~out of the region of~~ beyond possibility that they can require enlargement, which would of course involve a pulling down and reconstruction of the Channel; a reduction to the size of the present waterway can be easily managed by building up and diminishing the size of the opening. In every case, however, the Sill or flooring of the Rajbaha Channel is laid 2 feet above the bed of the Canal and of the flooring of the Bridge to which it is attached ~~floor near it~~; the object of this arrangement being to secure the passage of ~~an advanced movement~~ to at least 24 inches in depth of the Canal supply, and by these means to give water to the country ~~lying~~ in advance ~~to the lower districts~~, which had the Zumeendars in the upper districts ~~ones~~ the power to draw off the Canal to its bed, would in case of drought and when the competition was great, have in all probability no water at all. This point it will be observed has been particularly attended to in the Irigation outlets above the heads of the Falls; the Assoffnuggur and Dasna, which are the two extremes, and have to maintain a supply for a long line of country have their Sills constructed on a level with the Canal bed, by which

every

every advantage will be gained in the supply of the Rajbuha + lines, whereas those which lie im=mediately, have their sills + raised on a higher level, i.e. 1 foot above the bed of the Canal, so + that water equal in amount to that depth may pass onwards for the irrigation of the Districts ~~lying in the Lower regions~~

I don't consider that the close proximity of the East Kalli Nudui on the left of the Canal is to act in the smallest degree as a limit to the extent of Irri=-gation from the Rajbuhas or heads lying on that side;- by the use of masonry piers and open Sheet iron Channels stretched across them, the river can be passed without any difficulty, and the valley itself- is easily overcome by an earthen Embankment; the latter would in no instance exceed in dimensions some of the raised Channels which have been built in connection with the Rajbuhas on the Eastern Jumna Canal; that at Rundole, for in=-stance, which is upwards of a Mile in length, and with the bed of the watercourse raised 18 feet above the level of the valley The East Kalli Nudui ~~will~~ therefore will be no impediment to the Irrigation of the Country lying on its left bank.-

~~The capacities of the differ=-ent Sections of the Canal Channel, as described above, are as follows:~~ the values of R and b ~~being~~ are cal=-culated

+ With a maximum theoretical depth of water on the different sections of the Canal Channel as figured in the above Diagram the discharges will be as follows: the actual ca=-pacity of the channel being (from the circum=-stance of its being 2 feet deeper than that of max=-imum high water) being capable of carrying a much larger body of water than that theoretically assigned to it.

188329

=culated on even numbers, 5 being the limit in one case, and even hundreds in the other. —

Section						
No: 1						
2						
3						
4						
5						

It will be understood from the method of disposing of the earth which is excavated from the Canal Channel that the breadth of the esplanades on the top of the Em=bankments, where these Embank=ments exceed in width 20 feet, depends entirely on the Cubic Content of the Excavated Channel; With the exception of detached portions equal in total length to nine miles, the whole of the banks from Roorkee to the 180th Mile at Nanoon are much in excess to the minimum dimensions, they frequently occupy the whole Space between the berms and the Canal boundaries, and in this case offer a fine open esplanade for the purposes of roadway

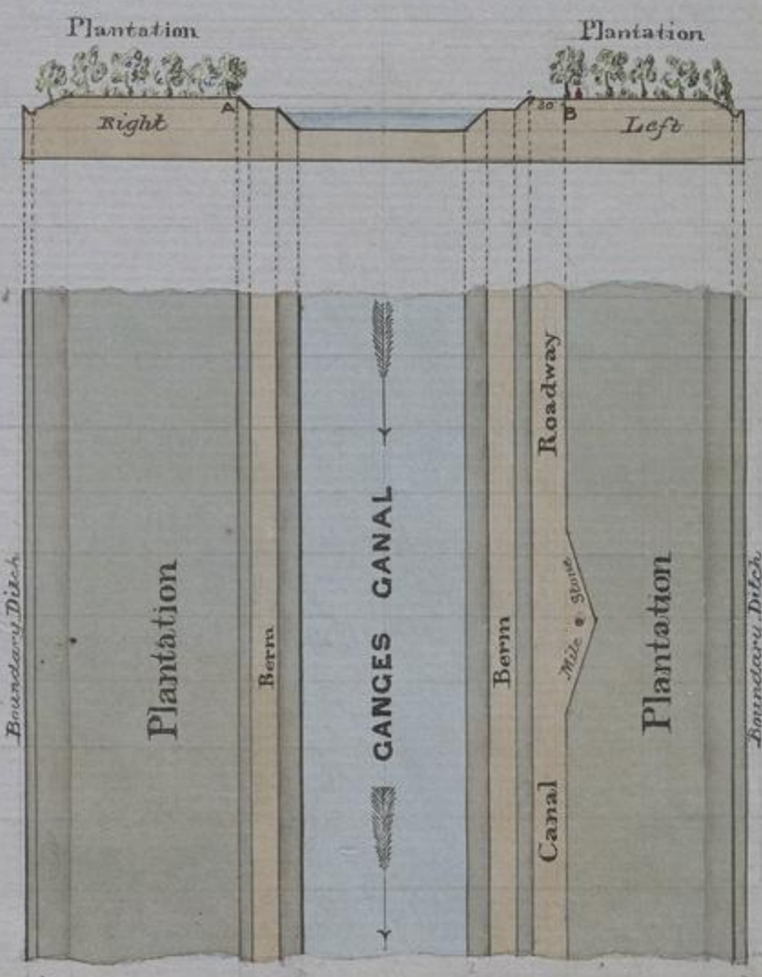
The maintenance of a line of roadway both for con=venience of communication, and for the purposes of patrol, is a point that has been anxious=ly looked to; this road is in some measure connected with the plantations, which are in=tended to occupy all the spare Space between the Canal bound=aries

66

=aries that is not required for other purposes. The general design and object of these plantations whether for forest or for fruit trees is explained in the Volume of Tables.

The following plan and section exhibits the lining out of the road, at a point where it comes in contact with a Mile Stone; these Stones are numbered from the Myapoor Regulating Bridge in a continued series to the end of the main Canal at Nanoor, they are it will be observed situated away from the road, in a platform kept clear for their especial purpose; they consist of a Square prism of Stone imbedded in a Cylindrical Mass of masonry, the top of which acts as a bench mark, and the figures engraved on the stone independently of the mileage, gives the exact depression of that particular point from the flooring of the Regulating Bridge at Myapoor

Diagram XXV



On

On the above diagram the width of the Bank is supposed to be much greater than that laid down as a minimum dimension, in fact as it really is on the greater part of this section of the Canal, the road is here 20 feet wide with an additional 10 feet between it and the plantations, so as to pre-vent the passage being interrupted ~~with~~ by boughs of trees; the road by these means actually maintains a width of 30 feet, it has a slight slope externally so that all drainage may flow away from, instead of towards the Canal Channel, and there is a low edging of earth carried along the crest of the interior slope for the pur-pose of preventing the action of the water from destroying its uniformity.

The above rule applies equally to banks of minimum dimension, the plantations being limited to a line B drawn in rear and on the low ground at the distance of 30 feet from the crest of the interior slope. Platforms of earth connected with and equal in height with the Embankment are in this case raised for the accommodation of the Milestones should such happen to occur on these narrow lines of roadway. In the sandy tracts the ~~road~~ surface will require some species of metalling, but in other parts the plain soil will ~~give a surface~~ be sufficiently even, and of suf-ficient durability to admit of its being kept in order. This

road

road is situated on the left or East side of the Canal when the direction runs from North to South; as by these means, the plantations give shade to the roadway in the earliest and hottest part of the day: the road is specifically for the Canal Establishment and for Canal purposes, and is not maintained as a public line of communication.

The Section given in Diagram XXV will shew the exact limits to which the plantations are carried, and the limits of annual clearance from grass, jungle and other nuisances that might impede the flow of the water; the lines marked **AB** define the portion in the vicinity of the stream that it is proposed to keep perfectly clear from jungle - within these limits no trees are to be allowed on any account whatever, beyond them the whole space up to the Canal boundaries is devoted to Plantations of Forest trees. I may observe that with a desire to secure good shade to the roadway I have planted a row of Mango trees on the line marked **B** throughout the whole length of the Canal. These trees at present are 100 feet apart, but when they have taken root and are fairly in progress of growth it is proposed to put in an intermediate tree of the same useful and ornamental quality. there is some difficulty ~~attending~~ in the Establishment of this species of Tree, as it is a martyr to the whole tribe of the White Ants, who attack it with remorseless severity; it requires care and attention

in

in being well watered during the dry weather, and it is much benefited by shade in the earlier periods of its career;- for these reasons I have restricted the number to a moderate proportion, so that the gardeners who are in charge of the different plantations may not be overwhelmed with their duties in securing the growth of this single line, the advantage of which 20 or 30 years hence, will be duly appreciated by those who have to travel along the Ganges canal works. It must not be understood that the Mango trees above referred to are Grafts, they are the common country Mango, which grows to its natural size, lofty in height and wide in its stretch of ramification. The plantations of "Grafted Mangoes" are confined entirely to orchards ~~which are~~ situated near the 1st Class Chokies, or main station points of the different districts which are on an average (with the exception of those built for Specific purposes at Falls and other large works) ~~throughout the whole line of the Canal~~ about 12 Miles apart from each other.-

The works on this section were divided into two portions, which have been carried on under the titles of the 2nd and 3rd Divisions. The 2nd, commencing at a point below the Assoffmuggur falls (above which the works as I have before described are included in the Northern Division) and terminating at the 110½ Mile or at

at the departure of the Bolundshuhur branch, was commenced under the Executive management of Captain A.D. Turnbull of the Engineers who in December 1817 was relieved by Lieutenant E Fraser of the same corps; on Lieut.t Fraser's departure on medical certificate to England in October 1830, Mr Frederick Read the Senior Assistant in the Division assumed charge of the works, and under this Gentleman's management, the Division has been brought to its present State of completion. The Futtiegurh branch, the works of which have not yet been begun, are included in the 2nd Division

The 3rd Division or that from the 110th to the 180th Mile, including the terminal works at each extremity have been begun and completed under the Supervision and management of McPhilips Volk. Both the Bolundshuhur and Koel Branches are included in the 3rd Division.—

CHAPTER IV

Head of Aligarh Canal to Cawnpoor

III "The Country from Nanoon to the "Ganges and Jumna Rivers, "marked by a deficiency of fall "in the surface of the Country, "and by its Connection with the "Rinde, Seyngoor, Pandoo, "and other Rivers which drain "the flat lands of the Centrical "Districts.—

"This Section includes both the Cawnpoor and Etawah Branches or Terminal Lines into

into which the main Trunk is sepa-
=rated at the Nanoon works: it
naturally, therefore, comes under
two heads, and as the line which
runs between the Pesum and Rinde
is that of my original Survey,
and that which was explained
in my report of 1825, I shall in
~~describing in detail~~ detail ~~of~~ the Country
below Nanoon ~~describe~~ limit myself first of
all to the Cawnpoor, or Easterly
Branch, ~~and~~ being that which is the
connecting link between the
Canal head and the Ganges River.
A few prefatory remarks, however,
regarding the site taken up for
the head of these Branches, and
the ~~object of selecting~~ motives for fixing it at
~~for this particular site~~ Nanoon will ren-
=der the details which follow
much more distinct and inter-
=esting.—

I have already referred to the
Seyngoor and Rinde drainage
as having influenced in a great
measure the direction upon which
the main line is carried from
the 152nd Mile, or from the neigh-
=borhood of the Town of Somna,
downwards; this drainage shews
itself in a very undecided and
unmarked character, along a line
of Country passing Koel, Alliguh
Nanoon, Akrabad and even to
a point as far as the Town of
Sikundra Rao; the direction of
this drainage inclines from the
East Kalli Nuddi, towards the
right of the Canal line: in the
neighborhood of Sikundra Rao,
however, another series of jheels

or

or extensive flats occur, and from thence rises the Cesun River, a line of drainage which keeps to the left of the Canal. In fixing therefore, a point for the head of the Branches it was necessary, in such a labyrinth of watersheds, to look to that which would give the greatest facilities for turning the heads of the different rivers for passing between those of the Rinde and Seyngoor attended by the least possible interference with the natural drainage; and by reaching Sikundra Rao and the Country lying to the East of it between the Cesun and Rinde with as little interruption as ~~possible~~ might be to the cross drainage escaping which lies between Akrabad and Sikundra Rao. The difficulties of this ground will be more clearly understood by a reference to the Map (Atlas Plate V), the whole surface was carefully examined, and the site at Nanoon, a village situated 2 Miles to the West of the Town of Akrabad, was determined on as that most convenient for the required purposes; it enabled us to reach the high land stretching between the Cesun and Rinde and upon which the Caunpoor Branch is directed with moderate interference from Country drainage, and it placed the Etawah branch on the Ridge between the Rinde and Seyngoor without any interference with their watersheds at all. I believe that the position fixed upon at Nanoon for the

Head

Head works of the ~~Branches~~ Terminal Lines, is the true one, and that by establishing the fork at that particular point we have by the least amount of artificial aid left Nature to carry out her own operations unimpeded. The design for the slopes of the bed of these branches is in both cases precisely the same, in the early part of their course, the slope of 15 Inches has been continued as far as the natural profile would admit of it. and when this ceases to be the case, the slopes are reduced to 12 Inches per mile; the superfluous fall being overcome by Masonry descents and lockage. the detail of this part of the work will be fully entered upon hereafter. — For the reasons above specified I shall commence the detail of the works below Nanoon by taking up those between the Rinde and the Cesun, and terminating in the Ganges River. This ~~line~~ Series of works is denominated

The Cawnpoor ~~Branch~~ Terminal line

The total length of this branch from the Nanoon Regulator to the Terminus on the Ganges at Cawnpoor is 169 Miles 3700 ft. After leaving Nanoon, and after having overcome the difficulties of the flats, and hollows between that place and Sikundra Rao, the Channel proceeds in an Easterly direction, keeping to the line of Main Canal of my original survey, and maintaining

an

an almost direct course centrically
between the Eesun and Rinde Rivers
as far as the 98th Mile at the village
of Dingri: South of this point the
Rinde River discontinues its paral-
-lelism with the Eesun and proceeds
onwards on a more Southerly course,
whilst the Pandoo River, the heads
of which lie on the left of the Rinde
and in the neighborhood of Subhus
and Bandmow (villages situated
to the South East of Dingri) takes
up the bearing which the Rinde
has deserted and continues on a
course parallel to the Eesun River.
At the 98th mile, therefore, the line
of Canal turns the heads of the
Pandoo and proceeds onwards
keeping to the left of that River,
and between it and the Eesun
until it reaches the 139th Mile;
at this point and on the left, the
Noon, a Line of Drainage connected with the
Ganges and the low land lying
between Cawnpoor and Baitool,
rises; keeping this low land con-
-nected with the Noon on the left,
and the Pandoo River still main-
-taining its parallelism with the
Canal proceeds onwards to the
village of Barah or to the 160½
Mile, from thence it takes a long
sweep to the North East, and passing
between the Town and Military
Bazars of Cawnpoor, enters the
Ganges River by a series of locks
and falls.—

The above general outline
will convey a tolerable idea of
the position which the Branch
occupies, with reference to the
Eesun, Rinde, Pandoo and Noon
Rivers

Rivers: I shall now take up the detail, on the system which I have before observed, of describing the works and the Country over which they pass in Specific distances of the course of the Canal: On this plan, commencing at Nanoon I shall take the first thirty Miles ~~which~~ which brings us to the high road ~~of cross communication~~ between the Towns of Eyta and Agra, and the Villages of Gudumpoor and Sawunt Khera ~~between~~ lie on opposite sides of which the Canal ~~passes~~.-

1st to 30th mile

With the exception of a slight curve which gives the Canal a direction to the South of the Town of Sikundra Rao, the bearing is throughout the whole of the 30 Miles from Nanoon to Sawunt Khera is almost due South East.- At points near the 4th, 6th, and 9th Miles, and before its arrival at Sikundra Rao, the line of Canal crosses low Country, which is connected with the heads of the Rinde, that at the 4th Mile ~~and~~ near the Village of Goodhoora, being the most distinct and traceable to a set of shallow depressions which lie on the North of Nanoon; from these jheels or hollows, the drainage appears to pass round on the North of Akraban, keeping to the West of the Village of Goodhoora, it then crosses the line of Canal and sweeping round the Village of Kunnukpoor, in a defined line of water course assumes under that shape the name of the "Rinde". The true Rinde may be considered as that above described, originating in low jheels

North

North of Nanoon; this line of drainage appears to be the most connected of the series; its indistinctness, however, excepting by actual Instrumental levelling, may be understood by its exceeding shallowness, the maximum depth of the main hollows which lie near Nanoon is only 3 feet below the surface of the neighboring country, whilst in its course round Akrabad and Loodhoona it does not exceed 12 inches in depth.- At the 6th mile and near the villages of Gopee and Rudain the hollow is of the same character in its immediate junction with the Canal, and the drainage appears to pass off towards the Rinde without any perceptible depression.- At the 9th mile the hollow bears some resemblance to that described as crossing the Canal at the 4½ mile, but it is less extensive although evidently connected with a quantity of uneven ground near the high village of Ginnowli lying on the right of the Canal, and under which the water passes off to the Rinde.- The following diagram gives a representation of the drainage above mentioned

15

Diag: XXVI

In carrying the canal ~~through~~ through ? the above 9 Miles of its course therefore, we have crossed three defined points over which the drainage towards the River naturally runs; on this length of canal there are three Bridges situated at Keylumpoor, Rudain and Ginnowli, each of which is provided with Masonry Inlets; these Bridge Inlets however are constructed more with a view to prevent the accumulation of water ~~caused~~ by the interference of the Bridge approaches with the drainage of the Country, - than to relieve the drainage of the Country itself; my object in all cases having been to turn rain water away from the Canal into the Rivers lying on the right or left, so that the Canal line may be perfectly free and un- =incumbered: the Inlets at the Bridges therefore would give little relief to the Country lying on the left, which had thus been cut off from its natural means of drain =age. To obviate the difficulties of our position in this neighbor =hood, an Escape Channel has been excavated from a point above the Ginnowli Bridge, or that which is situated on the lowest levels, to the East Kalli Nudee: and cuts have been made con- =necting the different hollows in the 4th 6th and 9th Miles with the Escape Channel: the drainage therefore will pass down parallel to, and on the left of the Canal,

and

and find an Escape in the
Channel above described - The
distance from the Canal at
Ginnowli to the East Kalli Nuddi
= di is 11 Miles and the Escape
Channel joins a Ravine near
the village of Chokra lying on
the Right bank of that River.
the difference of level between the
Sill of the Escape at Ginnowli
and the ~~bed~~ bed of the East Kalli
Nuddi is 28·67 feet or 2·42' per Mile.
the Excavation has from motives
of Economy only been carried to
a width of 10 feet, as the wear and
tear of the Current will, it is
supposed, widen it sufficiently
for all practical purposes. Ad=
=vantage has been taken of the
necessity which arose for excava
=ting the Channel and for connect
=ing the drainage with the East
Kalli Nuddi, to build an Escape
Head from the Canal Channel
with 18 feet waterway immediately
above the Ginnowli Bridge; we
have therefore the means during
the whole year, of using this Es=
=cape Channel for Canal purposes,
as well as for those of Country
drainage. As the Channel in
question crosses the Grand Trunk
Road, the bridge required for
the purposes of this Road has
been built with a waterway
of 30 feet in width, so that there
may be ample space for the
passage of the water, and ~~ample space~~ also
for any increased
width to the present excavated
line, which may ~~be derived~~ ~~from~~ the passage of flood water.
One advantage, and by no means

a

a small one of establishing a Canal outlet in connection with this ~~Canal~~ Aqueduct is that, if such should be necessary, an occasional scour can be given by passing a current of Canal water down it.

From Giminoli, the Canal passes onwards on the same bearing, leaving the Town of Sikandra Rao on its left at the distance of a mile; in the neighborhood of this town, encircling it in fact, are numerous shallow depressions, in which the Pesun River, which henceforwards becomes our left boundary, ~~drains~~ rises its origin; these depressions, with a profile of country very irregular (and as I have described elsewhere when pointing out the peculiarities of these Doab Rivers, so marvellously unobservable from their shallowness that the irregularities are only to be traced by the levelling Instrument) continue onwards parallel to, and as it may be said hinging the line upon which the Canal runs as far as the 2½ Mile, at which point and in the immediate vicinity of the Village of Sinwar we come in contact with one of ~~its depressions~~ them, which by being extended further to the South, forces us to cross it, under the disadvantage of much heavy Embankment.

This hollow ~~which goes by the name of~~ originally termed the Sinwar Jheel, lies due East and West; it is in the form of a Horseshoe with its toe

toe resting on the village of Sinwar, which is on its western extremity: the extent of this horseshoe surface is about One Square Mile, and its maximum depth below the Country in its neighborhood is Six feet, the Canal Channel passes through ~~this hollow~~ it on its full extent, and from having been more or less filled with water during the period that the works have been in progress, some annoyance has been experienced in the Embankment operations; its character, however, as a Wheel holding a prennial supply, which was that given to it by nature report, failed in the cold weather of 1853, when I found it dry or very nearly so, a circumstance that may have arisen from the Canal Excavations, although the Channel was completely cut off from the Expanse of the Wheel itself by heavy Embankments. It will be understood from the above description that a considerable portion of this hollow lying to the right of the Canal, ~~is~~ was cut off from its connection with the Escape and consequently from its natural line of Escape; this has been remedied by excavating a Channel from a point on the extreme East of the portion so cut off, towards the Rinde River, and by these means relieving the Country from any ill effects caused by our interference with the Wheel (see Diagram No XXVIII); the Cut thus made is in length 15250 feet, with a Bottom breadth of 5 feet, its average depth

depth being about 8½ feet, and I have no doubt that it will act in the most efficient way in relieving the country. The Esun River which in the neighborhood of the Siriwar Sheel lies at a distance of about 2 miles from the course of the Canal, turns off abruptly to the left on its approach to the village of Roostumgunj; and at the 30th Mile of the course of the Canal and below the point where the high road between ~~Cheyta~~ Eyta and Agra crosses it, the River and the Canal are separated by a distance of 5 Miles, whilst immediately Eastward of the same point and of the village of Sawunt Kheyra, the Canal comes in direct contact with the hollows of the Rinde, the tortuosities of the course of which are here very remarkable, its course in fact at the point in question is directly at right angles to that of its general alignment; it passes from West to East between the villages of Sawunt Kheyra and Gillowli

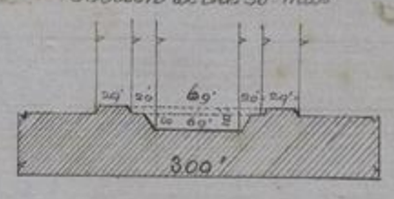
The strip of land over which the canal runs between the Esun and Rinde Rivers is exceedingly narrow, its maximum width is only 7 Miles and at the village of Khurgaon or on the 22nd Mile the width does not exceed 2¼ Miles The surface slope of the country from Kanoon to Sawunt Kheyra i.e. on a line of 30 Miles is 42:35 feet or an average per Mile of 1·41 feet.— The bed of the Esun or rather the country at the heads of that River in the early part of

of its course, is on a higher level than that of the Rinde; as the Rivers advance however, and when they obtain a more defined section, the true relative position of the drainage exhibits itself, at the 30th Mile a cross section from the Cesun to the Rinde shews that the bed of the former is 5'4½ feet below that of the Rinde, and the latter River maintains its elevation above the Cesun throughout the whole length of its course afterwards

The Section of the Canal at the 30th Mile is shewn in the following Diagram, the width of Rectangle which at the Nunoon Regulator was 80 feet having by a gradual reduction of 4:12 Inches per Mile, been diminished ~~to an extent of~~ 11 feet

Diag: XXVII.

Section at the 30th Mile



The depth of Canal water which on its approach to the Nunoon Regulators had been retained at 8 feet has been, by an extension of width to the Excavated Channels reduced to a maximum of 6 feet in the branches below them, the berm being maintained uniformly throughout the whole line at 8 feet in height, or on the principle which has been adopted on the whole work, at 2 feet above the high water mark. The remarks which I have before made on minimum

Section

section apply to the above diagram;
Excess of earth from the Channel
Excavations being used in widening
the bank to the Rear.—

Sy S = 256

The average depth of digging
on the line from Nanoon to Laurent
Kheyra, or on the first 30 miles of
the Cawnpoor Branch, is as follows.

From 1st to 10½ Mile = 0·53 feet
" 10½ to 20½ do = 7·75 "
" 20th to 30th do 4·1

The Soil is good though much
mixed with Reh (Soda) especially in the
neighborhood of Sainthra
On the upstream side of the Sudduw
=poor Bridge, or at the 29th Mile
there are traces of Bhoor or Sand
hills, but generally speaking the
Soil is harder and better than it
has been found in the upper Divi=
=sions.— The Canal bed throughout
the thirty Miles included in this
~~~~ is excavated on a slope of
15 inches per Mile, ~~is contracted~~
~~in advance on 12 Inches only~~.—

At the Keylumpoor Bridge
flooring there is a drop of 2½
Inches, the Canal bed on the down
stream taking up the lower level,
the drop was necessary to avoid
the heavy Imbankments that
would have been required in
advance had the Canal bed
been retained on the higher levels:
Locks and a navigable Channel
have been designed for the purpose
of overcoming the difficulty, and
of facilitating the passage of
boats; but the experience which
we have obtained in observing the
efforts
~~~~

effects of these Canals (these artificial rivers rather) to determine their own slopes, by the natural arrangement of silt deposits, has led me to defer the construction of the works for the purpose of passing boats round this descent, until we can see the consequences of admitting water and the effects of a running Canal upon the soil over which it passes.- A priori, the very circumstance of a sudden reduction of slope from 15 to 12 inches would lead to silt depo=sits, and to an equalization of the slope of the Canal from a point considerably above that where the change in the amount of level takes place, to one many miles below it, and as I believe that this will take place, and as I do not calculate on any very immediate demand for naviga=tion, after the water is first ad=mitted, I have considered that it would be unwise to hurry on the execution of works the uses of which may be problem=atical. The observation of a few years will at any rate settle the question, and will determine whether my anticipations are true or not; if they are not true the navigable Canal and locks can be constructed ~~without any difficulty~~ at a future period

The Maximum depth of wells, measuring from the surface of the Earth to that of the water is by observation in the Month of October equal to 32 feet the minimum equal to 16 feet —

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A.D. The

The following Masonry works have been built on this line

1st Bridge at Keylumpoor, with a waterway of 99 feet in 3 arches of 33 feet each, 20 feet Roadway and Plank towing path arches, with Ghats, Rajbuha Heads, Inlets and 2nd Class Choki attached. —

2nd Bridge at Rudain similar to that at Keylumpoor with 2nd Class Choki attached Roadway only 18 feet wide

3rd Bridge at Ginnowli similar to that at Keylumpoor with an Escape of 3 openings of 6 feet each with 2nd Class Choki attached Roadway only 18 feet wide

4th Bridge at Burramai 3 arches of 33 feet each, 20 feet Roadway with Plank towing paths and Ghats on the down stream

5 Bridge at Sikundra Rao (Poodilnuggur) same as at Keylumpoor with a 1st Class Choki [illegible]. —

6th Bridge at Sirsoli, similar to that at Keylumpoor with a 2nd Class Choki attached Roadway only 18 feet wide

7th Bridge at Dunsoi similar to that at Keylumpoor with 2nd Class Choki attached Roadway only 18 feet wide

8th Bridge at Futtanpoor 3 arches of 32 feet each with Ghats, Rajbuha and Inlet Heads. Plank towing paths arches and a 1st Class Choki attached. — Roadway 20 feet

9th Bridge at Bundi, 3 arches of 31 feet each. Roadway 18 feet. with Ghats &c and a 2nd Class Choki attached

10th Bridge at Guddumpoor 3 arches of 30 feet each. Roadway 20 feet with Ghats, Rajbuha and Inlet Heads and a 2nd Class Choki attached. —

Block

Block Kunkur has been extensive
=ly used in all the above works,
Excepting in the Arches, the Material
for making which has been con-
=fined to Brick.—

30th to 65th Mile

From the Bridge at
Guddumpoor over which the high
road between Clyta and Agra
passes, to the Bridge at Singpoor
which is directly opposite the
Town of Mynpoori, and is a
~~is~~ point on the high line of communication
between that Town and Etawah,
the distance is 35 Miles. The
line of Canal continues on the
same course, and on the same
bearing as it did ~~on its approach~~ in approaching
~~to~~ Guddumpoor making a slight
curve to the left on ~~its approach~~ coming near
~~to~~ Singpoor, to accommodate
itself to the general alignment
of the Rinde River between it
which and the Cesum River it
runs very centrically; on its
~~approach to~~ reaching the neighborhood
of Mynpoori, however, it bears
more upon the Rinde and op-
=posite the villages of Suthnee
and Dhulleepoor, or at the 6th
Mile, it passes within a quarter
of a Mile of that River

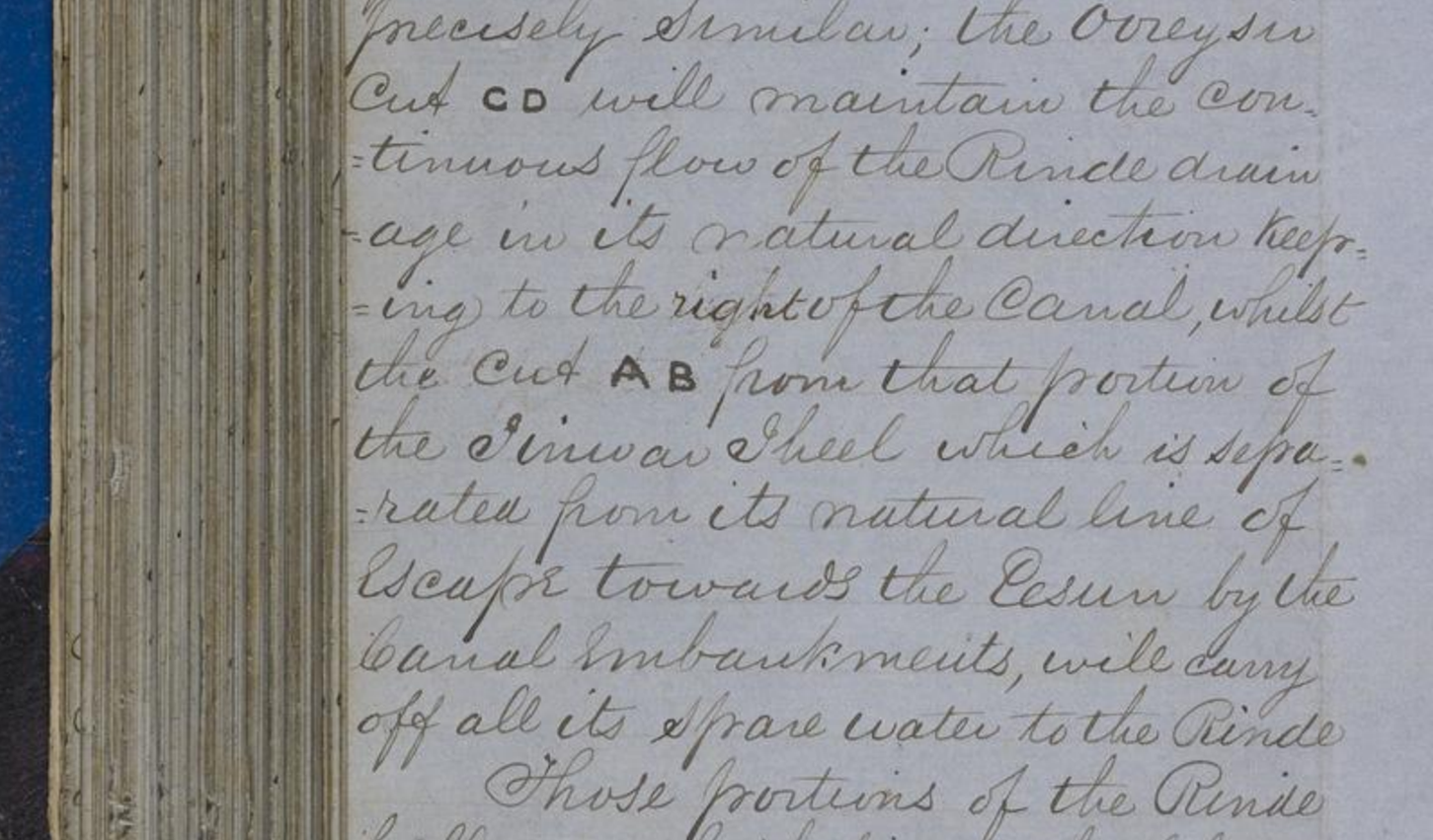
I have before remarked
that in the neighborhood of
the 30th Mile, and on the down
stream side of the Village of
Sawunt Kheyra, the line of
Canal comes in direct contact
with the course of the Rinde;
the intersection of these two
lines was unavoidable; it
takes place at two points, the

Canal

canal forming a chord, 4½ Miles in length, to of an arc represented by that portion of the Rivers course which is cut off; the perpendicular or versed sine of this arc is about 1½ Miles

The following diagram will shew the position of the works in this region, including those connected with the Jinwar Theel.

Diag: XXVIII.



The methods adopted both in the case of the Jinwar Theel the drainage of which flows towards the Eesun, and in that of the passage of the Rinde above described, are precisely similar; the Ooreysir Cut CD will maintain the continuous flow of the Rinde drainage in its natural direction keeping to the right of the Canal, whilst the Cut AB from that portion of the Jinwar Theel which is separated from its natural line of Escape towards the Eesun by the Canal Embankments, will carry off all its spare water to the Rinde

Those portions of the Rinde hollows which lie on the left of the Canal have been connected with the Eesun by the Cut EF leaving the higher levels between the

the villages of Kundpoor and Ninaoli of similar dimensions to those before described - This Cut is in length 21573 feet, with a slope of bed equal to 1·386 feet per mile. The slopes of the Rivers at this ~~part~~ part of their course, are small, and it is possible that the high water in the Cesun during floods, may maintain a back water inundation in the Rinde hollows in the neighborhood of Gopalpoor for a longer period than is desirable, this may be relieved by further cuts, entering the Cesun at a lower point of its course, and I may observe that the Inlet at the Gopalpoor Bridge, as well as that at Darvo ka Nugla, will afford relief to the extent of their waterway. This part of the Canal however, is one which as far as drainage is concerned, will require careful watching; and an energetic application of remedies adapted to the circumstances of the case. —

At the Gopalpoor Bridge which is situated in the Segment formed by the Canal and the old bed of the Rinde, a 1st Class Chokie post has been established with a view to the proper supervision and maintenance in efficient order of the different works in this neighborhood. —

From the Darvo Bridge or from the point where the Canal a second time intersects the

the Rinde River, the line passes onwards without any interference with drainage until it reaches the 41st Mile; both at this point and at the 42nd Mile, a series of hollows connected with the Eesun River is crossed, a portion of its drainage being cut off entirely: the following diagram represents the lining out of the drainage at Mokumpoor and Millowli, with the measures that have been taken to restore it to its proper equilibrium. —

From the 41st to the 65th Mile or to the end of that portion of the Canal which I am now describing, the line passes over a country tolerably free from drainage; at the 49th Mile, on the upstream side, ~~and forming part~~ of the works at the Nuguree Bridge, an Escape into the Eesun River is established. At this point the distance from the Eesun is 9000 feet and the slope from the sill of the Escape to the bed of the River is equal to 5·42 feet or an an average of 3·18 feet per Mile. This Escape has a water-way of 30 feet in 5 sluices of 6 feet each, and the Channel has been excavated on a width of

of 30 feet.. This Channel will be the ~~Medium~~ means of disposing of the water which collects on the lands East of the Villages of Oosneyda, Koonchul Ka Nugra, &c., as well as of that with which the Canal comes in contact at the 51st Mile; ~~This~~ the drainage is comparatively small, but it will be entirely relieved by the Escape Channel. Between the 51st and 52nd Miles, however, at the Village of Dhunni ka Nugla some hollows connected with the Eesun River, are crossed, and that portion of them which has been cut off has been relieved by a Cut of a Mile in length made into the Rinde: the drainage at this point, therefore, is effectively provided for. At the 53rd Mile also, and at a point where the ~~line of~~ Canal comes in close proximity to the Rinde River, ~~a line of~~ drainage which rises in the neighborhood of Nohneir crosses the line of Canal. This ~~Drainage~~ has been conducted into the valley of the Eesun by a Cut AB as shewn in the following diagram

Diag: XXX.

The strip of land lying between the

the Eesun and Rinde upon which the Canal takes its course, consists of a series of narow necks, connect=ing expanses of a width never exceeding 9 Miles, the necks them=selves being in some cases (as at the 49th and 57th Miles) not more than 2 Miles in width. At the Singpoor Bridge and at right angles to Mynpoori the width between the two rivers is equal to 6¼ Miles, and the Canal passes within 1 Mile of the Rinde.

The slope of the Surface of the Country from the 30th to the 65th Mile is equal to 43'28 feet, or an average equal to 1'24 feet per Mile. Cross Sections at the following points shew the relative position of the beds of the Rinde and Eesun to each other.

41st Mile Bed of Eesun 4'. 8" below that of Rinde
49th Do Do 7'.65 Do
*57th Do at Nohneia Do 9'.7 Do
65th Do Do 15'.46 Do

The bed of the Eesun it will be observed increases in depression below that of the Rinde as it advances in its course, the Eesun in fact at Mynpoori is a perennial River (supplied by Springs which rise on its approach to the Town from Nohneia) running through a very extensive valley; its value during

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* On a cross Section at this point the Bed of the East Kalli Nuddi near the villages of Bregumpoor and Khirni is 2'. 5 feet below the bed of the Rinde. The East Kalli Nuddi in the Month of April, when I took the Section, had water in it running slowly and sluggishly and full of weeds, the width of Surface was 115 feet and the greatest depth 3 ft 2 inches: both the bed and the banks in the neighborhood were sandy.

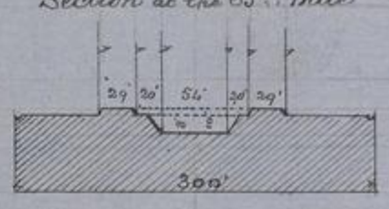
during floods may be estimated by the waterway of the Bridge which is built across it on the high road between Cawnpoor and Agra, the bridge consists of 2 bays of 30 feet each in width, connected to the high road by raised embankments or ramps of approach;- this waterway is in all probability somewhat contracted, as the bridge appears to have been injured by a flood as far back as the 21st August 1833: but it has nevertheless done its duty for a period of 20 years, and altho' its wings and superstructure require modification to meet the improved and well raised approaches that have been lately made, the bridge itself as far as waterway is con=cerned would most likely be sufficient for all practical pur=poses.- The necessity, however, for using the Cossin as an Escape from the Ganges Canal works, in consequence of the Slopes and Capacity of the Channel of the Rinde being insufficient, will render an Enlargement of the waterway of the Mynpoori Bridge necessary, and in this case the opportunity might be taken of carrying into effect the alterations recommended in 1833 by Colt. John Boileau of the Engineers in increasing the waterway; instead, however, of giving an additional width of 70 feet, I would give 3 additional arches of 30 feet in width, two on the North, and one on the South

of

of the present building - giving 5 arches of an uniform span and if possible I would make the roadway over it horizontal - The Bridge over the Rinde at Kulhore has a waterway of { Spring of arches 121½ feet / Foot of piers 111 feet } divided into 3 Bays of { 40½ feet / 37 feet } each, without any appearance of valley or running Stream which the Essen possesses to the great and apparent fertilization of the Country in its immediate neighborhood

The Section of the Canal Channel at the 65th Mile is as follows: -

Section at the 65th. Mile Diag: XXXI.



a gradual reduction having taken place in the width of the rectangular Channel equal to 28 feet in every 3 Miles. - The Minimum dimensions are then retained in the same way as formerly; the height of berm or towing path above the bed of the Canal being made of one uniform height of 8 feet, and where there was excess of earth beyond that required for the Minimum Section, the earth in excess was thrown in rear of the Embankments, so as to increase as much as possible the width of the Esplanade or roadway.

The average depths to which the Channel has been excavated between the 30th and 65th miles

are

75

are as follows:-

From the 30th to 40th Mile		7·71
Do	40th to 50th Do	6·94
Do	50th to 60th Do	6·6
Do	60th to 65th Do	7·02

The soil continues on the whole of this line of the same tenacious quality, occasionally mixed with Kunkur as it was on the Section before described; judging from the effects of rain water which during the progress of the works lodged in the Channel it is only slightly absorbent and through=out its whole course the influ=ence of Reh efflorescence is mark=edly observable:: this Reh efflo=rescence is characteristic of the whole line of the Mynpoori Dis=trict through which the Canal is carried it shews itself more or less on the surface, influencing in a great degree the extent to which Cultivation is carried, and in many parts of the excavated Channel it shews itself at depths considerably below the level of the ground surface. The brick Manufactories have suffered greatly from the soil being impregnated with this most destructive Alkali, and the consequences have been in many cases altogether fatal to the Manufacture of bricks, whilst on the whole line, there has been a difficulty in procuring this species of material, which has been unknown in the Northern Districts, ~~through which the Canal has been carried~~. The Slope of the Canal bed throughout the 35 Miles included in this Section

8/

is

is 15 Inches pr Mile.

The Maximum depth from the Surface of the Country to the Surface of the water in wells is equal to 28·8 feet, and the minimum 18·2 feet, the observations having been made in the month of October

The following Works have been constructed below the Bridge at Gudduspoor.

1st Bridge at Gopalpoor 3 arches of 30 feet each. 18 feet Roadway with Ghats, Rajbuha and Inlet heads, and a 1st Class Choki attached

2nd Bridge at Dharoo, 3 arches of 29 feet each. 18 feet roadway with Ghats, Rajbuha and Inlet Heads, and a 2nd Class Choki attached.

3d Bridge at Kylai. similar to that at Dharoo, but with a Roadway 20 feet wide. a 2nd Class Choki is attached to this work

4th Bridge at Kooreet. 3 arches of 28 feet each. 18 feet Roadway with Ghats, Rajbuha and Inlet Heads, and a 2nd Class Choki attached

5th Bridge at Mokumpoor, 3 arches of 28 feet each. 18 feet Roadway, with Ghats, Rajbuha and Inlet Heads and a 1st Class Choki attached.

6th Bridge at Nuguneea 3 arches of 28 feet each. 20 feet Roadway. with Ghats, Rajbuha and

and Inlet Heads; and an Escape with a waterway of 30 feet on the upstream side of the work - a 2nd Class Choki is attached to these works

7th Bridge at Puckowur 3 arches of 27 feet each - 18 feet Roadway - with Ghats, Rajbaha and Inlet Heads, and a 2nd Class Choki attached.

8th Bridge at Kurauli. 3 arches of 27 feet - 18 feet Roadway - with Ghats, Rajbaha and Inlet Heads, and a 2nd Class Choki attached.

9th Bridge at Dunahar 3 arches ~~Ducks~~ of 26 feet each 25 feet Roadway, with Ghats Rajbaha and Inlet Heads, and a 1st Class Choki attached

10th Bridge at Roostumpoor 3 arches of 26 feet each - 20 feet Roadway - with Ghats Rajbaha and Inlet Heads and a 2nd Class Choki attached. —

11th Bridge at Singpoor 3 arches of 26 feet each - 20 feet Roadway - with Ghats, Rajbaha and Inlet Heads - and a 2nd Class Choki attached. —

In all the above works, Kunkur has been very extensively used; the succession of failures in Brick Manufactories, and the consequent scarcity of bricks, would, in fact, have ~~indefinitively~~ delayed the completion of these works had it not been for the presence

presence of Kunkur Quarries which fortunately abound in the districts through which the Canal is now passing. The Material is excellent, but it requires to be carefully selected, and in all cases the blocks which have been used in building have been rigorously surveyed by the Executive Officer. —

65th to 100th Mile

Continuing our progress on another 35 Miles, or from the 65th to the 100th Mile, we reach the neighborhood of Dingri, and Rousa, two villages which are intimately connected with the lining out of the Canal as proposed in my project of 1845

The direction of the Canal after leaving the Singpoor Bridge is a few degrees more Southerly than it was in the latter part of its course, the bearing being influenced by the course of the Rinde, to which on the whole line it runs in close approximation; — in the neighborhood of the village of Tingea, and at the 85th Mile, at which point the line of Canal and the Rinde come very nearly in contact, the former takes a slight curve to the right and proceeds onwards in a straight line upon the village of Dingri. The courses of the Eesun and Rinde Rivers throughout the whole of the 35 Miles now under review, run on the most tortuous lines; although in a general way maintaining their parallelism to,

each

each other; the watershed of the Eesun River occupies the greater part of the intervening land, and in some cases stretches nearly to the Rinde, the Canal line has been laid down with the greatest attention to this particular feature of the drainage, and it passes as directly upon the crest of the watershed of the 2 Rivers as a straight line could possibly do upon a tortuous one; From the 65th to the 78th Mile, no drainage is crossed; the natural flow towards the Rinde on the Right, and to the Eesun on the Left, is unimpeded; on this line the village of Bhawunt, situated on a high mound to the left, and under which there are extensive hollows, is passed without the drainage in its neighborhood meeting with any check or impediment. At the 78th and 82nd Miles, we come in contact with cross drainage under circumstances of rather a peculiar nature; in the first case, a series of shallow depressions extending from the high mound on which the village ~~of~~ and old Fort at Nutpaon are situated, crosses the line of canal in progress to the Rinde; and in the 2nd case we come at the village of Dhundos upon a well defined crest of two Nullas, one of which passes by the village of Bussunpoor into the Eesun, and the other runs into the Rinde from the South of the village of Dhundos. This village is in fact

fact, built on the high land be-
-tween these two lines of drainage
on a space of about 1500 feet in
width, over which the course of
the Canal has been directed. —
The hollows in this neighborhood
are, as is frequently the case
throughout the Mynpoori Dis-
-trict, converted into Reservoirs
for the purpose of Irigation,
the remains of bunds or Embank
-ments, have come under my
observation as far back on the
line of Canal as the Village
of Nohnein, and in the hollows
connected with the Rinde, they
are of constant occurrence. At
the head of the Russumpoor Nulla,
and on the Puttaon line of
drainage they are eminently
conspicuous, their extent, however,
is inconsiderable; at the period
of my Survey in the Month of
December there was no appearance
of moisture in connection with
them, and their uses are merely
~~designed~~ for watering crops during
or immediately after the rainy
Months; it is questionable whether
after water is admitted into the
Ganges Canal, the system of
bunds on these hollows will
be continued. —

To remedy the evils arising
from the interference with the
Puttaon drainage, a Cut has
been designed for the purpose
of keeping the flow of water to
the left of the Canal and on-
-wards to the Russumpoor
Nulla

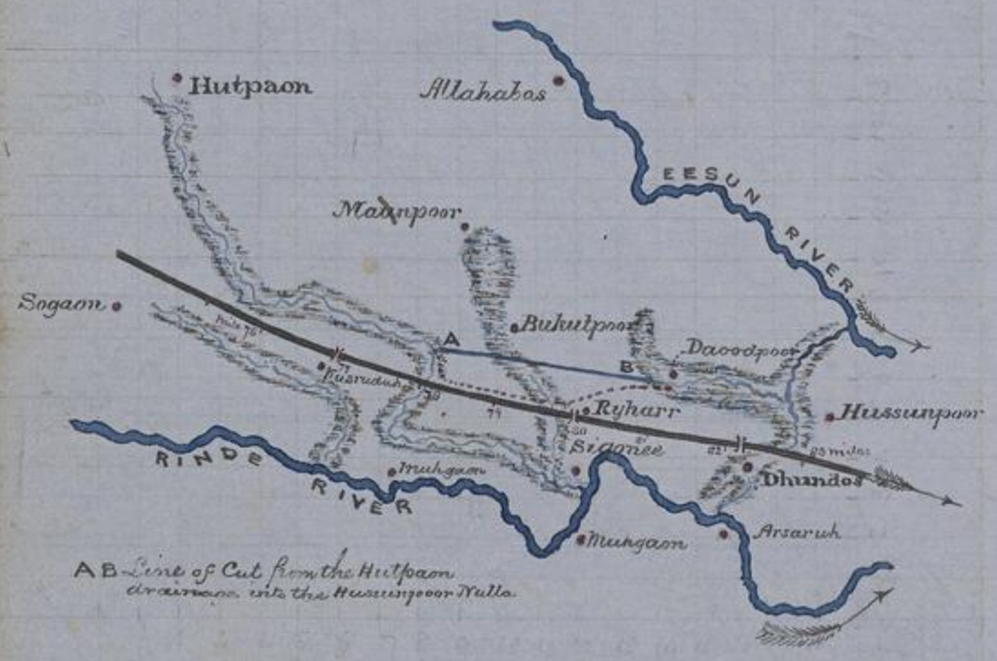
Nulla; the point at which this cut commences is taken on the deepest part of the Nuttpas hol-lows opposite the 78th Mile, or opposite to that point of the Canal where the natural drainage is intersected; from this point a straight line of excavated Channel with a rectangular width of 15 feet and with a bed slope of 2 feet p/m. Mile, will carry the water off to the Pesun; on its course it will pass directly through the Nuttpoor hollow leaving that village on its left, it will pass on the right and close to the village of Sobhunpoor; and at the distance of 3 Miles will meet One of the main heads of the Russunpoor Nulla under the village of Davoodpoor; two Miles more of excavation and clearance through the Russunpoor Nulla, will give the water a free Escape into the Pesun River and give full relief to the Country from Nuttpoor downwards*

The following Diagram will give a more accurate idea of the Rivers, and of the position of the works in this neighborhood than

* Economical considerations have led to a deviation from the above design The water from the Nuttpoor drain-age has at the 78th Mile been thrown into the left boundary ditch which has been widened for its reception — this ditch, at the 79th Mile receives the drainage from Mashnpoor, and at the 79¾ Mile of its course, it is connected with the Head of the Davoodpoor hollow by a cut passing to the East of Kyhuza See dotted line —

than I can convey in description

Diagram XXXII



From the 82nd to the 100th Mile, the Canal, although passing over a country intersected by Sheels, hollows, and lines of drainage of every description, and at one point almost touching the Rinde River, pursues an evenly lined out course, without in any way interfering with either the drainage of the Eesun or Rinde ~~Rivers~~. ~~In connection with this~~ On the upstream side of the Tirora Bridge, and situated at the 87th Mile, an Escape heavy with a line of Escape Channel into the Eesun River, has been constructed; this Escape has a waterway of 30 feet in 5 openings of 6 feet each, and is in design similar to those which have been built in the Bolundshuhur District. Plan and section of this work will be found in the Atlas Plate XXXIX The difference of level between the beds of the Rinde and Eesun on a cross section taken

on

on Virea is 16·68 feet; the Eesun, as I have before remarked, running in all its course on a lower level than the Rinde. The two Rivers are on this section characteristically represented; the Section of the dry bed of the Rinde being 70 feet wide, well defined, and with a bed de=pressed about 10 feet below the level of the Country: the Eesun, on the contrary, with a wide Sandy bed, and with its banks scattered over with Sand hills, runs on an ex=panse of valley green and fresh from its proximity to water: It is not, however, to be understood that the neighborhood of the Rinde is barren; in many places wheat crops exist in its very channel, its Slopes are constantly covered with Cultivation, but the differ=ence between it and the region of the Eesun in which there is a constantly running stream, and on the Slopes of which water is found at short distances from the surface is remarkable; the Soil in the neighborhood of the Eesun, moreover, is of a much lighter quality than that on the Rinde, the latter being in many cases a strong Clay, and frequently much mixed with Kunkur

The distance between the Canal and the Eesun at the point where the Escape is built is 8000 feet, and the difference of level between the Sill of the Escape and the bed of the Eesun is equal to 20·94 ft The excavated

Channel

Channel is 30 feet in width, with a bed slope of 1·5 per mile. The object of my selecting Tireea as the site of an Escape, and avoiding the line of the Russumpoor Nulla, which in my original project was the first fixed upon, was the desire to leave the Russumpoor Nulla, for the purposes of the Puttpao drainage; the slope of this Nulla as well as that of the artificial Cut to connect the Puttpao drainage, ~~the slope of this Nulla as well as that of the artificial~~ with it, is a good and a rapid one, and the advantages of scour which in the Gunnowli Escape Channel might be desirable, were of no moment at this particular point; in addition to this there was a greater and more immediate relief at Tireea than there would have been on the Russumpoor line.

The Canal throughout the whole of the 35 Miles above ~~Ca~~ Averaged Tabbee, is confined between the Natural boundaries with which it has been running parallel on its route from Nanoon: the Cesun and Ride which constitute these boundaries pursue with regard to each other the same irregular although generally speaking parallel course; at one time approaching to within a short distance; and at another wandering off in the most exaggerated series of curves and tortuosities. At the 100th Mile the departure

of

of the Rinde on a new line of bearing which separates it entirely from the Eesun River, gives an extension of width to the strip of ground over which the Canal passes which it has not had since its separation from the main Canal; at this point the width between the two Rivers is equal to 12 Miles, seven of which are towards the Eesun River. With the exception of that part of the tract near the Village of Tineea, where the above Rivers come within 3 Miles of each other, the average distance of separation from the 65th to the 100th Mile may be considered as about 6½ Miles. –

J. 278; V.1.

On the Surface of the Country the Slope from the 65th to the 100th Mile is 39·15 feet which is equal to 1·11 feet per Mile. The Canal runs upon the water shed between the two Rivers as closely as possible, and as before observed in closer approximation to the Rinde, than to the Eesun, a circumstance depending entirely on the position of the Ridge or watershed. Cross Sections at the following points shew the relative position of the beds of the Rinde and Eesun to each other. –

72nd Mile,	the bed of the Eesun is	8·35 feet	below the bed of the Rinde
82nd "	do	14·92 feet	do
87th "	do	16·68 feet	do
100th "	do	19·41 feet	do

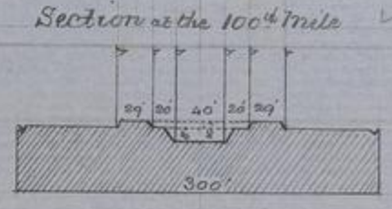
the gradual increase of depression of

of the bed of the Essun below that of the Rinde, is here as on the last 35 miles distinctly observable:- the fact is deserving of notice, as it points out the Essun River as one more capable of being useful in carrying off waste water from the Canal, than the Rinde, the slope of which laying aside the tortuosity of Channel which is common to both rivers, is ill adapted on this part of its course for the purposes of Escape.-

The Section of the Canal Channel at the 100½ Mile is as follows:-

Section at the 100th Mile

Diag: XXXIII.



a gradual reduction of 4 foot per Mile having taken place in the 35 miles just described.-

At the 71st Mile the slope of the Canal bed which had been continued at 15 Inches is reduced to 12 Inches per Mile, on which it is carried up to the 90th Mile. At this point and between the 90th and 102nd Mile, I have instead of giving a sudden drop as at Keylumpoor, and continuing the slope in advance at 12 inches per Mile, designed an uniform slope of 14 Inches giving to each Mile an excess of 2 Inches thereby adopting in preference to the drop, the form of an inclined plane.-

The

The rule for disposing of excess of earth and for maintaining the different parts of the Section are similar to those before described, the berm is kept at an uniform height of 8 feet from the Canal bed, and the maximum height of water is 6 feet.

The average depth to which Excavation has been carried is as follows:-

65th to 70th	Mile	10·03
70th to 80th	do	7·11
80th to 90th	do	7·7
90th to 100th	do	7·86

76

The soil is similar to that ~~described as existing~~ on the last Section, the same admixture by alkali, the same mixture with Kunkur, either in the form of gravel or detached pieces, or in tabular masses, and apparently retaining the same non absorbent qualities. It will be understood therefore that the manufacture of Bricks was here also a matter of serious difficulty, the absence of this material has in fact led to the reduction of our buildings to minimum proportions, and to the necessity of the strictest economy ~~with regard to the use of this species of Material~~ in the use of Brick Masonry; and had it not been for the Quarries of Kunkur, which have at detached points so conveniently, I may say providentially, offered themselves, the works in this Division, could not possibly have been completed at the early period that they

they have been

The observed depth of wells ~~on the above line~~ is on a maximum 33·25 feet, and on a minimum 16·41 feet, the measurement being taken from the surface of the earth to the surface of the water in the month of

The following works have been constructed on this line of 35½ Miles, and below the bridge at Tingfoor. —

1st Bridge at Putahar. — 2 Arches of 35 feet each 18 feet Roadway - with Ghats, Rajbuha and Inlet heads, and a 2nd Class Choki attached

2nd Bridge at Bhawind. — 2 Arches of 35 feet each 20 feet Roadway - with Ghats, Rajbuha and Inlet Heads, and a 1st Class Choki attached. —

3rd Bridge at Sogaon - 2 Arches of 33 feet each 18 feet Roadway - with Ghats, Rajbuha and Inlet Heads, and a 2nd Class Choki attaches. —

4th Bridge at Kussudh. 2 Arches of 33 feet each 18 feet roadway - with Ghats, Rajbuha and Inlet Heads, and a 2nd Class Choki attached. —

5th Bridge at Ryharr - 2 Arches of 32 feet each - 18 feet roadway - with Ghats, Rajbuha and Inlet Heads, and a 2nd Class Choki attached. —

6th Bridge at Dhundos - 2 Arches of 32 feet each - 18 feet Roadway - with Ghats, Rajbuha and

and Inlet Heads, and a 1st Class Choki attached

7th Bridge at Tirrea - 2 Arches of 31 feet each - 20 feet Roadway with Rajbaha and Inlet Heads and Ghats attached - Above the Bridge is an Escape of 5 Openings of 6 feet each - a 2nd Class Choki is placed between these works. -

8th Bridge at Futtepoor 2 arches of 31 feet each - 18 feet roadway - with Ghats, Rajbaha and Inlet Heads, and a 2d Class Choki attached.

9th Bridge at Mirzapoor. 2 arches of 30 feet each - 20 feet roadway - with Ghats, Rajbaha and Inlet Heads and 2nd Class Choki attached

10th Bridge at Dingri - 2 arches of 30 feet each - 18 feet Roadway, with Ghats, Rajbaha and Inlet Heads, and a 1st Class Choki attached. -

11 Bridge at Sooreya - 2 arches of 30 feet each - 20 feet roadway - with Ghats, Rajbaha and Inlet Heads, and a 2nd Class Choki attached. -

We are now at the point of the branch of the Cawnpoor line ~~from change at this~~ in the Original Project the Main Canal continued its course onwards, in one case towards Allahabad, and in the other (agreeably to the 3rd project of 1845) keeping to the left bank of the Rinde River to the Jumna

not

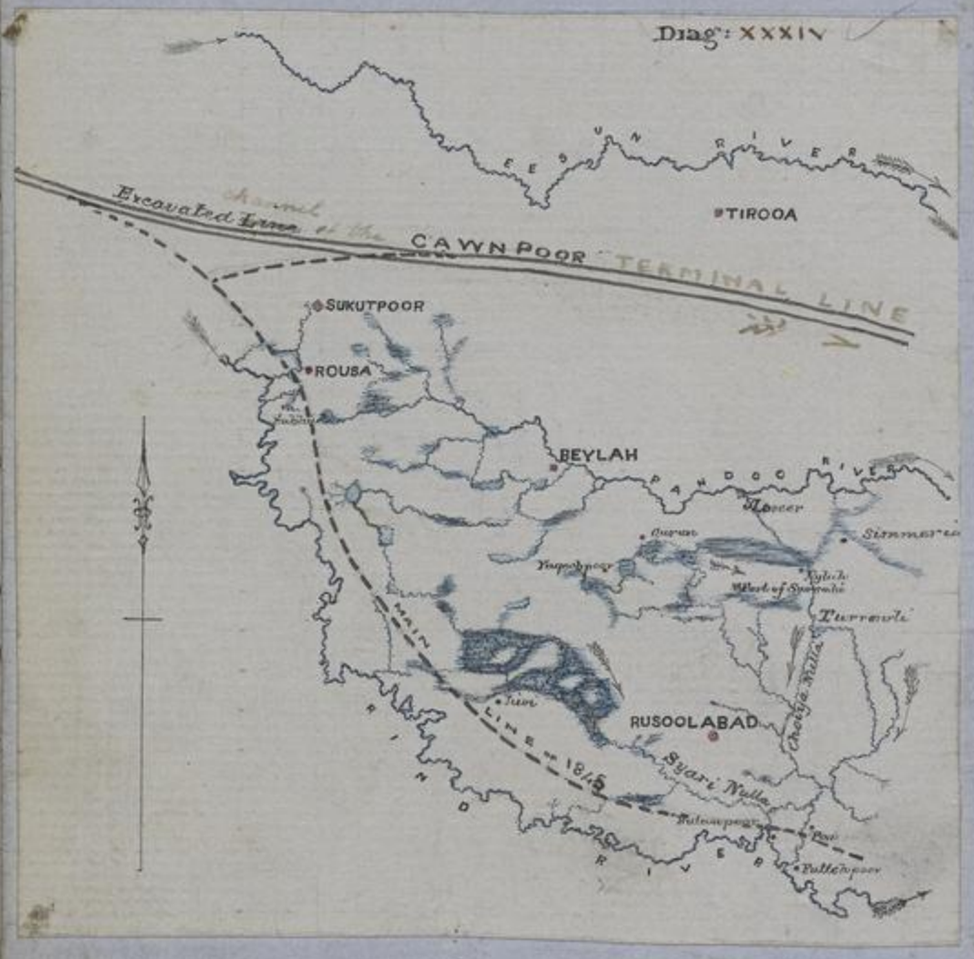
~~not far from~~ near the Town of Dar.-
This main line as far as the
village of Dingri, was precisely
the same as that upon which
the present branch has been carried.
From Dingri instead of proceeding
straight onwards to Cawnpoor
the original line took a Southerly
direction passing by the village
of Rousa, and by these means
escaped the heads of the Pandoo
River, which are situated in this
neighborhood on the left and near
the fort and village of Shishnud,
~~whilst~~ A branch to Cawnpoor
which was a component part
of the ~~th~~ project, left the main
line at a point above the low
lands which constitute the
head of the Pandoo River, the
site of departure being laid down
in the Map which accompanied
the report as near the village
of Rousa, although it was an
open question as to whether the
precise position for the head
would be actually at the point
so laid down, or at any intermediate
site between that place and the
village of Dingri. The site at,
or rather above Rousa had been
determined by me as that best
adapted to the watershed of the
Country, as by passing on the
right of the Towns of Turreen
and Sukkutpoor, the drainage
which rises at the former, and
passes off towards the Eesun
would have been avoided.-

The village of Rousa is
the

the Key to the passage of ~~this~~ that part of the Doab; ~~at this point~~ by turning the heads of the Pandoo at this point an open and uninterrupted pas=sage is obtained onwards to Allahabad, and it would have been impossible by any other direction to have avoided inter=ference with the actual courses of Rivers. It is unnecessary now to enter into details ~~upon this or=wards~~ further than to ex=plain that there is a great in=clination towards the Rinde of the drainage of the upper part of the Country upon which towards the Rinde the Pandoo takes its course and at a point near the Village of Doseer, situated upon that River and at a distance of 17 Miles from its head; the waters of the Pandoo do in very heavy floods escape to the South over a series of extensive flats on which the high mounds and Forts of Sirsahi, Simmeria and Turrowli are situated. In these occasions the flood is ten feet ~~Heads Entering~~ to the course of a well defined Nulla called the Chorja and enters the Rinde near the Villages of Poa and Ruttunpore In fact on the Triangle embraced by the Pandoo (which river runs from West to East) the Rinde and the Chorja, there is a tendency of the whole of the drainage to pass off to the Rinde, the natural line of watershed being close on the Right side of the Pandoo, and as ill marked and badly defined as a watershed could

be

be- The following diagram will render this explanation of Country more distinct.-



N.B. The dotted lines shew the direction taken by the main Line of Canal on its course towards Allahabad on the left of the Rinde River, and the Cawnpoor Branch agreeably to the Project of 1845-
The Double line AB shews the true course upon which the Canal and the works have been executed-
The arrows shew the direction of the drainage

The main line of 1845, it will be observed, instead of maintaining the high course near the right of the Pandoo, and mixing itself with the shallows and heads of the numerous lines of drainage between Rousa and Aoseer, kept to the left bank of the Rinde, and instead of competing in detail with such a labyrinth of drainage as the above diagram even will convey but an imperfect idea of; crossed it by Aqueducts at points near the Rinde where the sections of the Nullas in which it was collected were deep and well defined, One over the Syari to the East, and the

other

other over the Chonya to the west of the village of Ruttenpoor.

The relative levels of the Rinde and the Pandoo, and of the Country included between them on the line stretching from Rousa to Aoseer ~~is~~ are as follows:-

Bed of the Pandoo at Aoseer 27·7 feet

near Turnowli 29·89 "

Koorsi 49·88 "

Jakoobpoor 41·88.

Ouruw 41·77.

Sirsi 37·95.

*Above the bed of the River under the village of Aut. Temporary Embankment

The above description ~~of the position~~ of the early part of the course of the Pandoo River, and its relative levels with regard to the Rinde, and the country to the South and to the right of the line of the existing Canal, ~~as it has now been executed~~, will enable me to continue my narrative without interruption.- I may observe, however, in the words of my former report, and in recapitulation of what I have before said, that the Pandoo which takes its rise from the low ground in the neighborhood of Rousa, has its main sources at the junction of the Futtiguh Etawah and Cawnpoor Districts; it runs parallel to and North of the Rinde River on a much higher level, and in the early parts of its course exhibits ~~one~~ S. a Section of small dimensions with a declivity of bed not exceeding ten inches per mile; during heavy floods this River to a point as far East as the Fort and Village of

of Aoseer, overflows its banks,
and obtains relief by throwing
its excess of water into the Rinde
River, through a natural escape,
commencing in the neighborhood
of Aoseer, from whence by
Timmeria and Nyla it is
conducted by a series of Sheels
into a distinct line of Nulla,
which under the name of the
Choiya, joins the Rinde near
Russoolabad. Nature, therefore,
has placed the Country between
the Pandoo and Rinde at the
point in question under the
liabilities of flood from the former
river. The section of the country
from Aoseer on the Pandoo, to
the Rinde at the village of Poa,
taken down the course of the
Choiya Nulla, shews, that with
high water in the Pandoo under
Aoseer above six feet, the country
on the right bank, or on that
between the Pandoo and Rinde
would be flooded, and the escape
water would pass off down
the Choiya into the Rinde. —
The bed of the Pandoo under
the Fort of Aoseer is only two feet
below the bed of the Choiya
at the village of Timooli, the
land intervening not exceeding
four feet in elevation above the
bed of the Nulla at the latter
place. From the Pandoo at
Aoseer the Zumeendars have
excavated a ditch connecting
the River with the Sheels at
Timmeria

Simmeria and Nyla, for the purpose of supplying water for irrigation to the lands of these latter villages. The Pandvo and Rinde may therefore be said to be both naturally and artificially connected with each other. I would refer however for further explanation to Plate No IX in the Atlas in which the most detailed examination of this part of the country is exhibited.

Proceeding onwards from the 100th to the 135½ mile, we reach the 1st Class Choki and Station of Kukrwar. On this line the direction of the Canal is, as has been invariably the case during its passage between the Desun and Rinde, regulated by the course of the Rivers, maintaining its position as far as possible on the watershed; in the present case the bearing on its leaving the 100th mile is continued in prolongation of that which has preceded it for a short distance, it then takes a gradual sweep to the left, keeping to the right of and close to the high Mounds and Forts of Russeypur, ~~xxxx~~ Bahosi and Mujla; from thence the line proceeds onwards still keeping on a Curve bearing East until it reaches a point about half way between the Towns of Kurrood and Kitteea, where it takes a sweep round to the South

reaching

reaching the 135th mile at the village of Kukwan which is situated at a distance of a mile from the Pandoo River - The canal on this section of its course forms an ogee curve the lower point of which rests on the vil=lage of Kukwan; the object of this curve being to avoid the Pandoo drainage, and to thread one of the most intricate labyrinths of drainage, that can be imagined: its intricacies will be best un=derstood and appreciated by a reference to the Map (Plate No IX Atlas)

At the 102nd Mile the line of drainage to which I have be=fore referred as rising under the Ford of Tureend is crossed near the village of Kumsowa: the heads of this drainage shew themselves in a triangular hollow of about 2½ Square Miles in su=perficial extent lying to the North East of Tureend: its edge is situated within three quarters of a Mile of the Canal to which it lies parallel; and the centre of the hollow or of the head of the drainage is about 3 Miles from the point of intersection with the Canal at the village of Kumsowa; - at its approach to this village it assumes the form of a tortuous and well defined Nulla, and its inclination towards the line of works is unmistakeable: from the deepest part of the

Tureend

Turreena Theel to the bed of the Canal at Kunsowa the fall in fact, is equal to 3'91 feet. This nulla continues its course passing directly under and to the North of the Fort of Russeyrun, from whence it takes a northerly direction to the left of the Fort and mound of Sakh, and after passing over an extent of about 10 Miles, reaches the Eesun River at the village of Khurreapoor

From the most Southerly point of the Turreena Theel or from that which is in the closest approximation to the Rinde River, a Cut has been made by the Zumeendars of Gunnespoor, a village lying on the edge of a hollow connected with the Rinde, for the purpose of drawing off a portion of the Turreena Theel water for irrigation the length of this Cut, which is a mere ditch, is about 3/4ths of a Mile, it meets a line of hollow which extends for 1 1/2 Miles from North to South, on the westerly edge of which the villages of Rampoor and Gunnespoor are situated; at a short distance from the former village, a line of nulla runs into the Rinde. —

The following diagram will explain the nature and position of the different points alluded

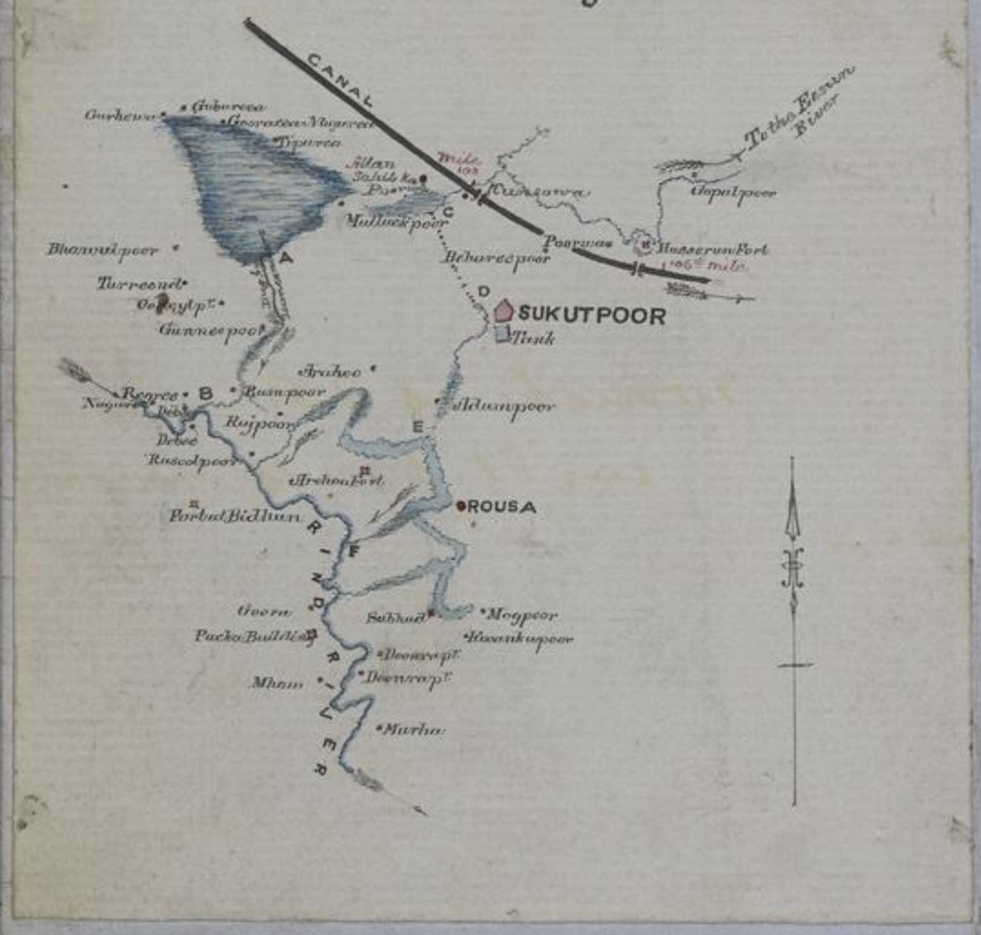
to

alder

Diag: 381

to

Diag: XXXV



It is in taking advantage of the line above described that I propose to relieve the Canal at Kunsowa, the actual distance between the edge of the Jureend hollow, and the heads of the Nulla connected with the Rinde under the Village of Rampoor is 2 Miles. the Cut for the purposes of drainage which is carried on the line of the Zumeendars ditch and through the hollow lying to the East of Gunneespoor and Rampoor, including clearances in the bed of the Nulla and Sheel, may be estimated at 2½ Miles in length, on a rectangular section of 15 feet in width; the slope from the point A to B is equal to 16·4 feet; the bed of the Cut therefore has a declivity of 6·56 feet per Mile.—

The bed of the Canal at the

the Kunsowa Bridge is 1190 feet above that of the bed of the Rinde at the point where the Rampoor Nulla joins it at Debee: the distance as the crow flies being 4 1/2 Miles.—

The Inlet at the Kunsowa Bridge ~~which is~~ Three feet in width will pass ~~—~~ off any superfluous water that may (as it may be expected to do for some years at least) keep to the natural line of Nulla.. To secure however the most perfect available escape for the water that annually collects on the right of the Canal and in the neighborhood of Nulla, a second cut marked in the above diagram CDEF has been made from the hollow near Allan Sahib ka poorwa to the line of drainage lying to the west of Sukutpoor, the whole of which flows towards the Rinde River The general slope of the Country on the right of the Canal being towards the Rinde, there will, I imagine, be no difficulty in disposing of the Deerend drainage in the direction of that River.—

From the 102nd Mile the Canal line passes onwards to the Village and Fort of Sooki with little or no interference with the cross drainage of the Country. The great Sheels or hollows lying to the left under the Forts of Bahosi and Mujla retain their natural outlet towards

towards the Cesun, and the Country lying to the right in the neighbor-hood of Sukutpoor, the Fort of Mow, Rammugger, &c., is drained without any sort of interference from the Canal works into the Rinds

At the Fort and village of Sooki, however, which are built on one of the numerous high mounds for which this part of the Doab is remarkable, the + Canal at the 115th mile of its course comes in contact with a hollow of considerable + dimensions; the alignement passes on its southern edge and between it and the village, and there can be no doubt passes on the precise watershed between the Cesun and Paindoo at this particular spot. Here, however, as in the case of the Tureend Sheel before referred to, although the true slope of the Country is towards the Cesun, and although the natural escape from the Sooki Sheel passes to the North and close under the Fort of Bimnowra, the slope is so small and the hollows and Sheels with which the line of Escape is connected are so intangled, that had it not been for the most intricate in-strumental examination of the Country, I question whether the true watershed could have been discovered; - as in the Tureend Sheel also, here are two cuts made by the Zumeendars from the

Southern

Southern face, one on the west and the other on the East of the Ford of Sooki, the former leading the water from the Sooki Wheel into a long line of hollow, over which a bund or embankment has been thrown for the purpose of forming a reservoir for irrigation; the latter for the supply of a set of hollows lying to the Eastward over which there is a series of bunds applicable to the same purpose, and all of them put to use annually during the rainy season.

Both the Cuts above mentioned connect the Sooki Wheel with the Slope towards the Pandoo River, they run in fact over the watershed: and it will be interesting to the reader to refer to the Map on which the detail of this particular part of the Country has been ~~introduced~~ ~~Expressed~~ (Plate IX. Atlas) ~~that the~~ by which he may understand the nature of this network of drainage ~~may be fully understood~~.

In advance of the 115th mile the Canal passes over an even country until it reaches the 120th mile at Khynuggur, at this point it crosses a low tract which is on the watershed, leaving on the right a large hollow situated to the North and under the ford of Khynuggur; and on the left a more extensive and more straggling depression of Country lying to the South of the village of Goorowli, ~~and~~ between

between that village and the
line of Canal, At the 121st Mile
the Canal ~~in fact~~ crosses a piece
of low ground which connects
the Goorowli Theel, with the
hollows that run under Khyr-
=nuggur, and which ultimately
joins an extensive series of
Theels, in the neighborhood of the
two forts of Dunkut and Chung-
=unwa, the water from which
flows into the Rinde - The drain
=age from the Goorowli Theel
naturally to the Panaoo, and a Cut 1½ miles long has been made to a Nulla connected
runs with the Cesun - The Canal
on its onward course sweeps
round to the North of the Forts
of Dunkut and Chungunwa
and the low ground which lies
in this neighborhood, and at
the 126 and 127th Miles reaches
the village of Aima by crossing
a piece of low ground which
has been artificially connected
with an extensive hollow &
lying on the left of the line, under
the Mound and Fort of Roums.
From this hollow under Roums
the Zumeendars have excavated
two lines of ditches for the pur-
=pose of drawing off water to
their Dams and Reservairs &
lying to the South and in the
neighborhood of Dooloo and
Ruheempoor - Here, as in the
instance before described of the
Sookli Theel, the watershed has
been cut by Channels for irriga-
=tion, over these, however, the
Canal line passes, separating
the Theel at Roums from the
low land of Dunkut and
Chungunwa

Chunguwa; the direction of the drainage from the neighborhood of the Fort of Rouns is towards the Cesun River, which lies at a distance of 4½ Miles, running in a deep valley bounded by Ravines, which are pierced in the direction of Rouns by two lines of well defined tributaries for the reception of the drainage. it is possible that the relief of heavy inundations near Rouns may be facilitated by an artificial Cut,* made from that neighborhood, or from the Wheel itself to the heads of these tributaries, but as the necessity for making it is not very clear at present, I have not included it in the Operations which have been carried on during the progress of the works I may remark in this place however, that although the extension of artificial lines for the above purpose not only here but elsewhere, would undoubtedly add greatly to the relief of the County, by rapidly carrying off rain water to the low boundary lines of the Cesun and Pandoo, we may by so doing cause considerable injury to the Cultivators who at present husband the supply for the purposes of irrigation, and are by no means desirous of allowing the water to escape; in how far the introduction of Canal water, and the system of regular irrigation thereby

* This Cut has been dug since this was written. —

thereby produced, may affect
the System now in force by the
Cultivators it is not easy to say,
but it would be unwise, to de-
=prive them of their present
means, before we are able to in
=sure a substitute, I do not
therefore, advocate any further
drainage by artificial cuts
than that which may be ab-
=solutely necessary for main
=taining a natural equilibrium
to the escape of flood water. —

From the 127th mile the
direction of the Canal pursues
its curved course keeping
close to the drainage which
runs towards the Pandoo
River, and in this curved course
running parallel to and within
a distance of 1½ Miles from the
River: At the 133rd Mile, and
near the Village of Munowa
it crosses on its watershed a
branch of the Orunu drainage;
this branch which is connected
with an extensive series to be
hereafter described, slopes towards
the Pandoo; but its dimensions
are small, the water that ~~is~~
passes off to the Pandoo is ~~of~~
~~a~~ limited in quantity, and its
connection with the Orunu
drainage at all may possibly
~~in all possibility~~ have arisen from
artificial causes; at any rate
the drainage is not impeded
by the Canal, which passes
onwards to the village of
Kukwan without any further
inter

W. Ettshier

interruption. —

The Ouun drainage to which I have before referred becomes of importance in its connection with the Canal with which (under the name of the Noon River) it runs for a considerable distance, parallel; it requires therefore some explanation. —

Ouun, which lies on the left, and to the North of the Canal, is, like Sooki, Nusseypum, Yakoobpoor, and other places of that description, situated on a high mound, it might be called a mountain, did it not owe its existence to artificial ~~means~~ causes. The whole country lying under the influence of the heads of these Doab Rivers, and of the Net work of drainage which is their most remarkable feature, is studded with elevated Mounds of this description; from the Heads of the Seyngoor and Rinde throughout the Cawnpoor District as far as the country over which the Canal passes, these mounds are of constant occurrence; in the neighborhood of the heads of the Seyngoor and Rinde, the Forts of Bijeegurh and Awa, are characteristic examples; in the country in the neighborhood of the heads of the Pandoo, and at that point where the Etawah, Futtiegurh and Cawnpoor Districts meet, they are numerous; they exist both on the Dumna and Ganges

side

sides of the Doab, and in many cases, are so extensive that it is difficult to imagine that they are artificial, ~~but that they are so there is no doubt what=ever~~. Their origin may be traced to the most remote antiquity, and to a period ~~in all probability~~ antecedent to that of recorded history. Originating ~~in stronghold~~ in all probability ~~solely for defence~~, and in masses of earth piled up for the purposes of Mud forts they have from generation to generation received accessions of material from the Country lying at their feet, and in the decay and renovation of Mud walls and habitations built under ~~the~~ their shelter. The extensive and shelving hollows which in=variably lie at the feet of these mounds, are in themselves proofs of the ages that must have elapsed, in bringing them into that condition, ~~and in removing all traces of artificial excavations, exhibiting them~~ ~~in fact~~ To the eyes of the present generation, these excavations show themselves in ~~and~~ expanses of shal=low shell and wide spreading lake, with no trace whatever of artificial origin. —

these excavations show themselves in

It is not to be understood that the mounds to which I refer are mere conical eleva=tions; in many cases (in il=lustration of which I may note Bawund and Bahosi) they consist of ridges, ram==ifying from a centre, and rising from the surrounding

Country

Country to a height not exceeding 120 feet. The Forts and Castles with which they are crowned are in the present day, with the exception of a few cases in which like Awa they have been retained as the mansion or Palace of a native Chief, in ruins; and the villages which from their elevated site are naturally attendant upon them, are in most cases at the present period clustered round and at the foot of the slopes. Often, however, the mounds are deserted as at Tureend, and the village is altogether detached to a spot sufficiently elevated in the neighborhood. I have no doubt that excavations in these mounds, although neither so interesting nor so productive as those on the banks of the Nyis, would add greatly to the elucidation of their early history; very extensive foundations built entirely of blocks of kunkan, are frequently laid bare, by the action of the rain water; in a variety of cases, pieces of Hindoo sculpture, terraces, and remains of Mundirs or Hindoo Temples, the architecture of which differs widely from that of the present day have been found; and at Bahosi a figure about 12½ feet in length, in deep relief, of Hunooman carved in large masses of kunkan, has by some enterprizing person been rescued from its obscurity, and placed erect in a building designed

apparently

a,, roaemtle for its especial protection

There can be no doubt that these mounds and the excavations from which they have originated, have in a great measure influenced the drainage of the country, as they most undoubtedly have, in some degree, determined the position of the canal works; the description therefore above given, may not be considered altogether discursive, topographically and archæologically speaking, they are of very great interest. —

Ourun with its mound, fort, and attendant hollows, may be considered as lying at the head of an extensive line of drainage which keeping to the left and to the north of the Canal, reaches the village of Nurroa and thence proceeds onwards to the Ganges under the name of the Noon River. The hollows connected with Ourun [extend to the north of that village to a distance of 3 Miles, and in the direction of the Fort of Rouns to which I have before alluded, and are only separated from that line of drainage by a tract of country of 1½ Miles in length; the levels of this tract are of no great elevation, and it is by no means impossible, therefore, that during heavy falls of rain, and when inundations arrive at their maximum, the superabundant water from the country in the neighborhood of

Rouns

Sée V. P. 289

Roums passes off down the Ourum drainage and ultimately reaches the Ganges by the Noon River; it is under this idea that I would recommend, should the above Speculations be correct, or should the Roums Theel give any trouble, that a Cut ~~should be~~ be made connecting that Theel with the heads of the Ourum drainage

From Ourum the drainage which lies on the left at the distance of half a Mile from the Canal forms two distinct lines of depression, that on the west passing by the Villages of Ajmuthpoor and Gunhewa and approaching the line of Canal within a quarter of a Mile near the Nunoora Theel; and that on the East passing the Forts of Salempoor and Suttipoor at a distance of 2 Miles from the Canal; the fort of Suttipoor being isolated by two transverse lines of hollow which connect the East and West Series of drainage. The two parallel lines above described meet at the Village of Luchmunpoor situated about a Mile to the left of the Canal at its 141st Mile and from thence in a tolerably well defined Nulla the drainage passes off on an Easterly direction, leaving the Villages of Bakur=gunj and Gowri on its right. ~~and~~ near the Village of Indhunna it joins a Nulla with somewhat of

of a larger section which is called the Noon; this River rises in the latitude of and about 4½ miles east of the Village of Munowa, it constitutes in fact a third to the two parallel lines, which I have above described, into which the Ounum drainage separates in its course between Munowa and Nurowa; its heads however are distinct from those of Mun-owa, being separated by an elevated tract of a Mile in width.

From Indhumna the drainage under the name of the Noon, passes away in a South Easterly direction, parallel to the course of the Pandoo River, and at a distance of about 5 Miles from it; the depression of country increases with great rapidity as it advances, and in the neigh-borhood of the Grand Trunk Road at Chobipoor, the Noon and one of its tributaries are crossed by 2 Bridges, that which spans the larger River having a waterway of 58 feet, in 3 Arches one of 30 feet & two of 14 feet span, the other having a waterway of 30 feet in one Arches ~~of~~ 30 feet span; the River enters the Khadir or low land of the Ganges, after running a course from Ounum of 26 Miles at the Village of Birheeya.

With the exception, therefore, of a point at the 113d Mile where the Ounum drainage escapes over a narrow neck of hollow

hollow into the Pandoo at Munowa, and thereby is intersected by the Canal; the whole of the drainage to the Eastward is directed towards the noon and its tributaries; the Canal is in consequence carried over a Country high and dry, and under these favorable Circumstances it reaches the village of Kukwan at the 135¼ Mile.

Immediately above the Kukwan Bridge an Escape head of 30 feet waterway in 5 Openings of 6 feet each, has been built for the purpose of giving an outlet into the Pandoo River. this work is on the same design as those which have gone before it, and the apparatus for the management of the sluices is precisely the same; the width of excavated Channel is 30 feet and its length is 5550 feet. The difference of level between the Sile of the Escape and the bed of the Pandoo is 11·99 feet, or 11·4 feet per Mile. At Kukwan is a 1st Class Choki and a main Station attached to the Escape.

Throughout the whole of the 35 Miles, above described, the line of Canal passes intermediately between the Pandoo and the Resun, the Rinde in advance of the 100½ Mile of the course of the Canal having passed away to the South, and the Pandoo having assumed the place of that River in its parallelism and propinquity to

to the Cesun.. The strip of land through which the Canal passes between the Cesun and Pandoo, averages 10 Miles in width, its narrowest point, in the latitude of Roums, being only 6 1/2 Miles.-

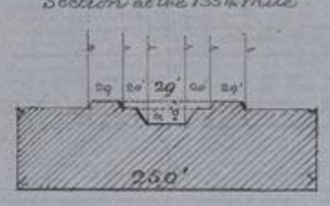
The Slope of the Surface of the Country from the 100 to the 135th Mile is equal to 35.18 feet, or on an average of 1.005 feet p/m. Mile, the Canal runs on the Water-shed as closely as the regularity of alignement would admit of; it rather inclines to the Pandoo, and its general direction is determined by the bearing of the Rivers.. Cross Sections at Different points shew the relative levels of the beds of the Pandoo and Cesun to each other as follows:-

10th Mile between Bahosi and Indunguik	Pandoo above Cesun	22.81 feet
32nd Mile at Ouun	Do	23.89 "

The Section of the Channel at the 135th Mile is thus

Diag: XXXVI

Section at the 135th Mile



a reduction of 11 feet in width of rectangular Channel having taken place in the last 35 Miles. The disposal of excess of Earth has been arranged on the same plan as before described; the berm has been formed on one uniform height of 8 feet from the bed of the Canal, and the Maximum height of high water is still maintained at 6 feet.-

The

(with exception to the first 2 miles which have a Slope of 14 Inches per Mile) -

The bed slopes of the Canal Channel have been made ~~cut on~~ on one uniform level of 12 Inches per Mile, and the average depth to which Excavation has been carried is as follows: -

100th to 110th Mile	7·15
111th to 120th do	11·16
120th to 130th do	7·65
130th to 135th do	7·18

the Soil is hard and tenacious and as far as I can judge, of a very Non absorbent quality it is similar in all respects to that which I have described as existing on the last Section

The observed depth of wells throughout this length of 35 Miles is on a Maximum 36·5 feet, and on a Minimum 13 feet, the measurements being taken from the Surface of the earth to the Surface of the water

The following works have been constructed in advance of the Tooreya Bridge. —

1st Bridge at Kunsowa of 2 arches of 30 feet each - 18 feet Roadway - with Ghats, Rubbuhs and Inlet Heads, and a 2nd Class Choki attached. -

2d Bridge at Busseynun similar to that at Kunsowa but with a Roadway 20 feet wide - a 2nd Class Choki is attached

3rd Bridge at Bahosi - similar in every respect to that at Kunsowa - with a 1st Class Choki attached. —

4th Bridge at Goonaka, similar

similar in every respect to that at Kunsowa; with a 2nd Class Choki attached

5th Bridge at Oomurdu similar to that at Kunsowa. with a 2nd Class Choki attached

6th Bridge at Sookhi. with a waterway of 50 feet in 2 arches of 25 feet each - Roadway 15 feet wide. Ghats, Rajbuha and Inlet Heads, and a 2nd Class Choki attached.

7th Bridge at Khyrnuggur similar to that at Sookhi with a 2nd Class Choki attached

8th Bridge at Aima - similar to that at Sookhi - with a 1st Class Choki attached

9th Bridge at Barrapoor similar to that at Sookhi, but without Ghats, Rajbuha Heads or Choki

10th Bridge at Bidhun 50 feet waterway in 2 arches of 25 feet each - 18 feet Roadway with Ghats, Rajbuha and Inlet Heads, and a 2nd Class Choki attached.

11th Bridge at Ootha - similar to that at Bidhun with a 2nd Class Choki attached

12th Bridge at Munowa similar to that at Bidhun with a 2nd Class Choki attached

13th Bridge at Kukrwar waterway, Ghats, Rajbuha and Inlet Heads, same as at Bidhun - Roadway 20 feet wide - An Escape of 30 feet waterway, and a 1st Class Choki are attached to these works.

From

Plume

135th Mile to Ena

From the Station at Kukwan or from the 135th Mile, the Cawnpoor Branch continues on another length of 35 Miles, at the termination of which it falls into the Ganges River.

The direction of the line which continues on the same curve as that upon which it reached the Kukwan Station, is carried to the South and clear of the Ourum drainage; at the 139th Mile it takes a sweep to the right (at the 156th mile near the village of Kooroolee) passing equidistantly between the high banks of the Ganges and the Pandoo Rivers ~~(at the 156th Mile) near the village of Koorsoolee~~. From thence on a gradually increasing curve with the high banks of the Ganges still on its left, the Canal crosses the high road between Kalpi and Cawnpoor at the village of Khujoori, and the Grand Trunk Road near the village of Duknapoor; it meets the Cawnpoor Cantonment on the boundary that separates it from the City; along this boundary the Canal passes, and after crossing a portion of Cantonment land reaches the lower levels of the Ganges River in a fall of 45 feet in 5 drops of 9 feet each The line of Canal throughout the whole of the 35 miles which I am now describing passes on a series of Curves, threading the intricate drainage which intersects this portion of the Cawnpoor District; these Curves have in fact continued uninterruptedly

=terruptedly from the 100th Mile downwards, and have generally speaking been laid out with great correctness, and on as long radii as possible; the general aspect of this portion of the Course of the Canal will be best understood by referring to Plate IX of the Atlas.

From the 135th Mile which is the point upon which this Section commences, down to the 145th Mile, the Channel proceeds uninterruptedly and unimpeded by drainage of any sort; it passes within a quarter of a Mile of the Nurwa Sheel which lies to the East opposite the 138th and 139th Miles, running parallel, and at an equal distance as far as the Village of Kumalpoor. At the 145th Mile, near the villages of Runsa Ka Nawada and Bakungunj, the Line crosses a small ~~line of~~ hollow connected with the Oonun drainage; by this intersection a portion of the Oonun drainage of about One Mile in length is cut off; this will be thrown into the Pandoo, if necessary, by a Cut* made from the Right of the Canal to that River: the amount of drainage, however, so cut off is inconsiderable, and it is very questionable whether any steps will be required for its relief, this is a point amongst others upon which I should be disinclined to spend money, until an experience of a few Years proved the necessity of it.

From

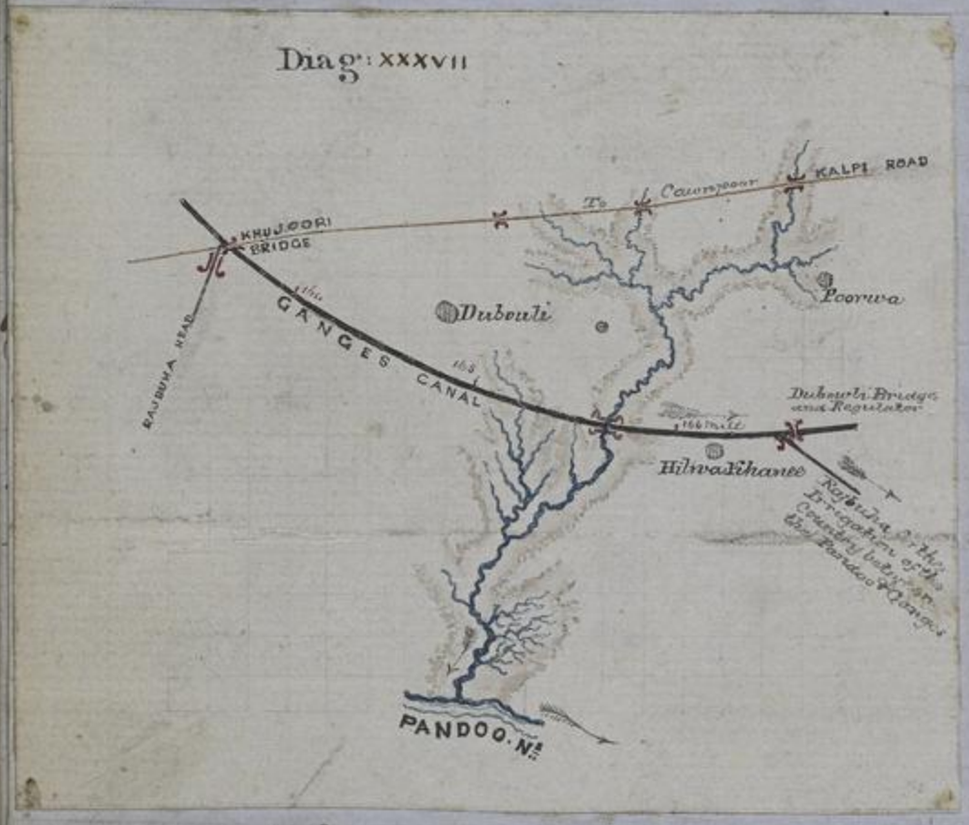
* This Cut has since been made - The is 5 feet wide at bottom - The cut through the Canal bank afraid that their village would be injured -

From the 14th to the 16th Mile the line passes over a high country uninterrupted by drain=age until it reaches the neigh=borhood of the village of Dubooli, at which point it comes in contact with a hollow connected with the Pandoo River, this hollow is crossed by a set of works combining the passage of the hollow by an aqueduct with a free water way for its drainage, and a series of outlets for escape from the Canal; these works are, in fact, the Regulating Head of the Canal on its ap=proach to the Ganges, and are the commencement of a series of works, connected with the lockage into the River, and with the Irigation of the country which we leave on the right, and which terminates at the junction of the Pandoo with the Ganges ~~River~~.

The Dubooli drainage which is crossed by the works above alluded to, is of no fur=ther consideration than that without making a great and a very awkward detour, the Canal line could not have been carried in any other way than it has been: the site however, is peculiarly applica=ble to the demands which the Canal works called for, for Escape in their neighborhood, and the position of the hollow with reference to its proximity to the Pandoo, and the capacity of both for the purposes of carry=ing

=ing off the Escape water, are circumstances in every way favorable to the uses for which they are required.—

The following Diagram will explain the relative positions of the Canal, the Pandoo, and the country with which we come in contact in the neighborhood of Dubowli



The extent of country lying on the left of the Canal and which comes under the influence of the Dubowli drainage does not exceed 1 Square Mile; its boundaries are well defined, and the waterway for its drainage consisting of 3 passages equal in width to 6 feet each which pass under the Canal will be quite sufficient for its relief. The Escape from the Canal Channel consists of 6 waterways of 6 feet each, 3 on each side of the Canal, and so arranged that their Escape water shall fall upon the lower levels under every

402 Z01

every advantage for the rapid passing off of the water. The difference of level between the bed of the Canal, and the bed of the Subpassages for the Dubowli and Escape drainage is on its upstream side equal to 6½ feet; the beds of these Subpassages having a Slope equal to 2 ft. in 107 ft. - From the upstream edge of the Subpassage to the bed of the Pandoo River there is a fall of 21·91 feet on a distance of 9000 feet, the average Slope therefore is equal to 12·85 feet per mile. The Nulla from the works towards the Pandoo will be straightened and cleared out to a width of 15 feet and every facility will be given to the escape of both drainage and escape water

Immediately in advance of the Dubowli Escape and drainage works is a bridge for the convenience of the village; to this Bridge a regulating Shutter is attached at a point just below the head of a Rajbaha, with a waterway of 10 feet in width which is intended for the head of supply of Irrigation for the tract of Country lying between the Pandoo and Ganges; this supply will not therefore be cut off when the Shutter is closed for the purposes of the Dubowli Escape, or at periods when it becomes necessary to prevent the Canal supply from proceeding onwards towards the works at

Cawnpore

Cawnpoor. The supply for Irriga-
-tion under these circumstances
will in no way be interfered
with, and the Rajbaha itself
will in addition to its uses as
a line for irrigation, act to the
extent of its capacity of Channel
as an Escape. These works at
Dubowli, in which I include both
the Escape heads over the line of
drainage and the Regulating
bridge with its Rajbaha Head
will I anticipate place in the
Executive Engineers hands, a per-
-fect control over the water during
flood periods, and enable him
at a moments notice, to lay the
Channel which passes through
Cawnpoor perfectly dry

In advance of the above
works and at the 168th mile, the
Canal is crossed at the village
of Duknapoor by the Grand Trunk
Road from Allahabad to Delhi
the Bridge at this point is with-
-out Rajbaha Heads, and is built
on a Skew at an angle of 65
degrees, the direction of the Canal
on this line has been advancing
on a gradual curve from due
East to North, and on the latter
bearing it proceeds nearly on
a straight line from the Duknapoor
Bridge direct to the Ganges River

At the distance of 800 feet
in advance of the Grand Trunk
and the Bridge at Duknapoor
the line of Canal ~~in~~ passing
a collection of Brick Kilns
which lies on the edge of the

Town

Town of Cawnpoor, reaches the
Cantonment boundary; on this
boundary, and for a short distance
separating the Cantonments from
the Town, the line of Canal proceeds
Onwards passing through a portion
of the Cantonment Land, on a
straight, or very nearly a straight
line until it crosses the "Course
bridge", or that bridge which in
=terSects the main Cantonment
drive. from thence it takes a
slight curve to the left, and by
a Series of drops of 9 feet each,
gains the levels of the great
River.—

It is a characteristic fea-
=ture of the profile of the ground
on its approach to one at least
of the banks of the ~~~ Rivers
in the Doab, that there should be
a gradual rise of Surface; this
is ~~ universal on the left bank
of the Jumna, as well as on the
left bank of the Rinde ~~at~~ all
~~their points cross~~ with which the Canal
works have been connected; it
was remarkably shewn in the
Surveys of Country on the lines
of Canal which were originally
proposed towards the Jumna
both at Allahabad and Dar,
and in both cases the Amount
of depth of digging which
this increasing elevation of
surface as it approached the
banks of the River led to, was
one great cause of the expense
attendant upon these lines. On
the Cawnpoor Branch which I
am now describing, this pe-
=cu

=culiarity is as prominently
marked as it was elsewhere,
and on the last 18 miles of its
course, the Excavation which
throughout the Cawnpoor Dis=
=trict had averaged 8 feet in
depth, increased to from 10 to
16 feet, the latter dimension being
that on which a considerable
portion of the Channel was ex=
=cavated; the depth of digging
on the line which passes through
Cawnpoor was on an average
12 feet, through a soil that was
hard and tenacious at the
surface, but Sandy below: it
became necessary, therefore, to
design a series of works that
would maintain the Channel
in efficient order, prevent the
falling in of Slopes, and retain
the water within accurate and
well defined limits: it was also
a matter of consideration, to ren=
=der this portion of the Canal
which was so directly connected
with a large and Populous
Town, ornamental as well as
useful, to relieve the bridges
and works for cross commu=
=nication which were necessarily
numerous, from the ~~bulkiness~~ extreme and
rigid simplicity which had been
adopted elsewhere; to give means
of approach to the water by
Ghats or Stair cases, and to pro=
=vide every reasonable accommo=
=dation to the community in
Wharfage and Quays for the pur=
=pose of loading and unloading
merchandise

Merchandise. An extensive system of inlets connected with the drainage of the Country lying in its neighborhood was also one of the leading features in the proposed improvements.

Alder.

For a proper understanding of the works which have been constructed in the Town of Caunpoor, Plate XLIV, of the Atlas must be consulted. In a general way, however, they consist of a double line of Revetments on an upper and lower level, with bridges for cross communication. Opposite each main street, these bridges form the Canal into a series of bays, which terminate on the approaches to the head of the Locks; from thence the series of works continues to the River, each Lock having its passage for cross communication, and its quays for the landing of goods. The Terminus which faces the River has been designed in extensive Ghats or flights of steps situated on the right and left of the entrance into the Lock Chambers, these Ghats are backed by domed Pavilions, constructed on native models, and the descent from the upper levels which is gained by a double line of steps is flanked by pedestals for the reception of sculptured figures & emblematical of the great River. The plan

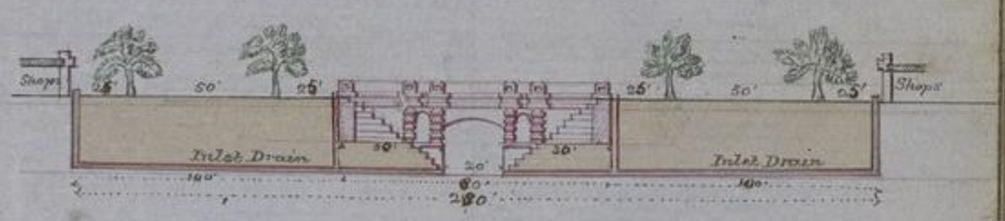
and

and Elevation of this Terminus are designed as closely as possible to meet the habits, and accord with the tastes of the Native community; and as its architectural character is intended to harmonize with the Town and Ghat Scenery lying in its neighborhood, ~~we can hardly regret~~ a departure from the usual routine of building on European Models, which are perhaps neither so picturesque, nor so well adapted to River Scenery, as those of India, may be excusable.

To effect a passage for the Canal through that portion lying on the boundary of the Town of Cawnpoor, which is denominated General Gunj, a good deal of House Property had to be purchased, the property was entirely limited to that on Cantonment ground for which no ground rent was paid, and the tenure upon which it was held was that common to all lands belonging to a Military Cantonment, viz^t: that it was reclaimable at any period, on proper remuneration being rendered for the buildings which had been erected upon it. In the present case the value was determined by a Committee of Military Officers which was assembled for the specific purpose, and the award in money was paid summarily by the Executive ~~Officers~~ Engineer in Local charge of the Works

Works; there were fortunately on the area upon which the line of Canal fell no buildings of any importance. A Mosque which came within the bound=ary has been allowed to re=main, and as much indul=gence in this respect as could be allowed with reference to the projected lining out of the works was uniformly granted. The width of ground between the two lines which were fixed upon as the Canal boundaries, was determined at 280 feet, and the general design for laying out this ground will be understood by the following Diagram, shewing a transverse section on the line of Clearance

Diag: XXXVIII



The Canal Channel as it will be observed runs centrically through the Space lying between the boundaries having on each side a clear Esplanade or roadway equal to 100 feet in width. These Roadways are flanked by the Town and Cantonment build=ings, which it is proposed to lay out in lines parallel to the Canal, and with Façades of uniform Street architecture. Lines of Mangoe trees planted at a distance of 60 feet apart will

will divide the esplanade into a centrical carriage road of 50 feet in width planted by open ~~lines~~ avenues for foot passengers. I have selected Mangoetrees for the purpose of these avenues, because they give the best shade of any tree indigenous to this part of the country; I have rejected the Neem (Melia Aza=dirachta) which in the Cuttack District is a tree of the most umbrageous and noble charac=ter because it is not from choice planted by the natives in the vicinity of their towns and residences; it is not, more=over a fruit tree, nor does it produce the depth of shade which is so peculiar to that from the Mango

The design for drainage is shewn in the above section The esplanade slopes in a very small degree towards the Façade at the foot of which is a drain which receives not only the rain water that falls on the esplanade, but that which falls on the Streets running at right angles to it; this drainage passes off by per=pendicular wells (or Bombas to use the native expression) which are situated at distances along the line, the wells them=selves being connected with underground Channels (as shewn in the above section) which pass the water off to the Canal; ~~Channel~~ Bombas of a similar design to plan 2 in the Survey of the Pontoon Troop.

The Bombas,

or

or main hills (as they are adapted to sending down a man or boy for clearance) are protected at the top by a wall or parapet; they are in fact mere copies of similar works which may be seen stretching across the Country in the Neighborhood of Delhi; the remaining ~~banks~~ of extensive Sewerage and of underground Channels for which the old city was celebrated.

The numerous Inlets from the Town and its neighborhood, will it is expected introduce large volumes of water into the Canal below the Daboowli Escape, and between them and the heads of the Locks; to remedy this inconvenience, an Escape with 2 Sluices of 6 feet in width each has been constructed in connection with a Ravine which under the name of the "Church Nulla" passes off to the left, and ultimately reaches the Ganges River. This Nulla which is in fact a mere Ravine, and only loaded with water during the rainy season, will I imagine, be greatly benefitted by occasional scours, and by its being converted into a well regulated Channel, kept under proper supervision.

The above description of the works in Cawnpoor will I believe give a fair idea of the design upon which they have been constructed; they have occupied ground formerly encumbered by houses and huts, encircling pools of stagnant wa-

-ter

=ter, and connected with every
species of filth and want of
ventilation; they have been
the means of not only getting
rid of the pools and ponds
which came within the region
of the Canal boundaries, but
of filling in others, and of level
=ling and equalizing the ground
in the neighborhood; Ravines
and hollows by no means
adding either to the salubrity,
or to the appearance of the place
have been filled in, and their
Space has been occupied by
Roads, Esplanades, or buildings.
Mills for grinding corn have
been constructed in connection
with the locks, means have been
given by the locks for raising
boats from the Ganges to the
higher levels, and thereby, for
unloading their cargoes in the
immediate vicinity of the Town;
facilities for bathing, which have
never before existed have been
introduced into the very heart
of a densely populated City;
and, perhaps, one of the greatest
improvements which the works
have led to, is the advantages
derived from ventilation by
the opening of a centrical
line of broadway, or Promenade,
with its attendant conveniences
of shaded avenues.-

The Military Cantonment
of Cawnpoor the boundaries of
which at the present time, are
of a very irregular description,
may by the agency of the canal
works, be placed on a more compact

footing

footing - I have before stated that the Canal on passing a series of brick kilns and on its arri=val at Cawnpoor comes in con=tact with the boundary sepa=rating the Town from the Military Cantonment; this boundary however, is continued along the edge of the Town which lies parallel to, although at some distance from the banks of the Ganges; the Can=tonment lands therefore, separate the town from the River by a narrow irregular strip varying in width from ½ to 1½ miles, and extending as far as 3 miles upstream to a point on which the Ordnance Magazine is situated; this long strip of land is occupied by Barracks and Parade grounds of the different Corps both Eur=pean and native; and as it will be understood from the above description is crossed by the line of the Canal on its approach to the River. The Canal in fact di=vides the Cantonment at a nar=row neck where its width between the Town and the River is three quarters of a mile. The following Diagram which gives an ac=curate representation ~~of the~~ of the lines of the boundaries of the Military Cantonment with reference to the Town of Cawnpoor, will be suggestive at once, of the facilities which the Canal works offer for re=modelling the Cantonment boundaries, should such be considered at any future

time

time advisable

The alteration which I would propose, and which, in fact, cannot help striking the eye of any one who looks at the present straggling nature of the Cantonment, and the extreme inconvenience of its ~~present~~ existing boundaries with reference to the Town, is simply to remove the whole of the Corps which are now cantoned on the left, and on that strip which separates the Town from the River, to the right of the Canal to make the Canal line, the Western boundary of the Cantonment, and to give up to the Civil authorities the whole of that narrow strip which now separates the Town from the River. By these means the Cantonment would be compact, its Police arrangements would be infinitely less complicated than they are at present, and its connection with the Town would be cut off by the well defined, broad and open Esplanade through which the Canal runs. Whether the inconveniences of removing the

Barnett

the Troops from the West to the East, and the sacrifice of so much Barrack room and public property would militate against the above arrangement. I am unable to say; it is a fact, however, that very extensive barracks and public buildings are now lying on the East of the Canal line deserted, in consequence of the reduction of the Cawnpoor force; these Barracks and these buildings are therefore available, and their existence is somewhat in favor of the removal of the troops to that side of the Canal. At any rate by reducing the extent of the Cantonments which in consequence of the great reduction of the Military force (more than two thirds) is occupied by people utterly unconnected with the army from its present unmanageable length of 16 miles to a more compact dimension of 3 (which, moreover, is infinitely more in accordance with the wants of the Force in its present strength) the Government would in addition to the advantages already pointed out, gain a very considerable accession of valuable land, the Return from which would repay them over and over again for any sacrifice that might be made in the desertion of public buildings, or in the expense of the removal of troops

The Canal in its passage through the last 35 miles of its course keeps as I have before described.

Sig. X P. 305. V. i.

described on the high ridge
which separates the Pandoo
from the Noon and the Ganges
Rivers; in the early part it runs
in close proximity to the Ooroo
drainage, its direction onwards
being guided by the course of
the Pandoo and by the low
land of the Noon which at
the villages of Puntabpoor and
Koorsowli approach to within
2½ miles of each other - On this
high land the Canal takes
its course leaving the Noon, to
which enters the Ganges to the
South of Bithoor, and proceeds
onwards parallel and close to
the Pandoo River to the point
where it comes in contact with
the Dubowli drainage; from
thence it takes a turn towards
Caunpoor, deserting the course
of the Pandoo entirely; the
latter River continues onwards
in a South Easterly direction to
the boundary of the Caunpoor
and Futtehpoor Districts, upon
which it passes to the North,
and joins the Ganges River on
the boundary of the Binaki
and Sark Saleempoor Purgunnas;
from the point whence the
Dubowli drainage enters the
Pandoo, to the junction of that
River with the Ganges, the course
of the Pandoo may be estimated
as running, in all its tortuosities,
on a length of 40 Miles: its course
is parallel with the Ganges, and
the two rivers in their progress
from Caunpoor and to the point
of junction enclose a tract of
highly

highly cultivated Country of about 25 Miles in length by an average of 8 Miles in breadth, or a Superficial area of 200 Square Miles, all of which will come under Irrigation from the Raybuka head at Dubowli.-

From the village of Kukwan to the Town of Cawnpoor, the strip of land between the Noon and Pandoo along which the Canal runs, is variable in width, but it never exceeds 6 Miles - The fall of the Surface of the Country from Kukwan to that point on the high land at Cawnpoor from whence the slope towards the River commences is 25 1/2 feet in a length of 33 Miles or .78 feet per Mile. between that point and the Surface of the Ganges River, the distance being about 2 Miles, the fall is equal to 56·58 feet. -

Cross levels at different points shew the relative levels of the bed of the Pandoo River with the Country on the left, or with the low land in which the Noon and Ganges Rivers run. -

Koorsowli - 56th Mile - Pandoo below Country where the Canal Crosses	}	Feet 15·39
- 56th Mile - Low Ground of the Noon, at 1½ Miles from the Canal	}	13·5
Dubowli - 61st Mile - the bed of the Pandoo at the junction of the Dubowli drainage appears by a cross section taken by Lieut Charles Hutchinson of the Engineers to be only		12·93

12·93 feet above the Surface of the Ganges River at a point under the old Town of Cawnpoor, and near the Village of Nuwabgunj; immediately at the junction of the high bank of the Khadir with the running River —

the level of the Canal bed on the Sill of the Dubowli Escape is 21·91 feet above the bed of the Pandoo River at the junction of the Dubowli drainage. —

The Section of the Canal Channel at the point where the Grand Trunk Road crosses the line near the Village of Duknapoor is as follows: —

Diag: XL.

Section at Duknapoor

The height of the berms from the Canal bed having been reduced from 8 to 6 feet &. from the Dubowli works downwards

The bed slopes of the Canal are maintained on a declivity of 12 inches per mile, and the average depths of digging throughout this section may be estimated as follows: —

135th	to 140th	Mile	6·32
140th	to 150th	do	8·20
150th	to 160th	do	9·76
160th	to 170th	do	9·71

The Soil from Kulleean downwards is of the same te-

-nacious

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-nacious quality as I have before described it to be in all the ex-
-cavations that have taken place in the Cawnpoor District; it is only in the deep digging on our approach to the Ganges River, where we come in contact with ~~the~~ sand.-

The observed depths of wells measuring as usual from the surface of the Earth to that of the water is on a maximum equal to 57 feet and on a minimum equal to 14 feet.

From the Bridge and Escape at Kuskwan the following works have been constructed.—

1st Bridge at Mudhoopoor 2 arches of 25 feet each. Roadway 18 feet wide, with Ghats, Rajbuha and Inlet Heads, and a 2nd Class Choki attached.—

2nd Bridge at Koondun of 50 feet water way in 2 arches of 25 feet. Roadway 15 feet neither Ghats nor Choki are attached to this work—

3rd Bridge at Tuktowli similar in every respect to that at Mudhoopoor, with 2nd Class Choki attached.—

4th Bridge at Bhosari. of 30 feet water way in 1 arch Roadway 20 feet wide. with Ghats, Rajbuha and Inlet heads, and a 2nd Class Choki attached

5th Bridge at Duggutpoor of 30 feet waterway and 18 feet Roadway; with Ghats, Rajbuha and Inlet heads, and a 1st Class Choki attached

6th

6th Bridge at Runjeetpoor
similar to that at Duggutpoor
with a 2nd Class Chokie attached
7th Bridge at Doorkapoor
similar to that at Duggutpoor
with a 2nd Class Chokie attached
8th Bridge at Koorsowli
similar to that at Duggutpoor
with a 2nd Class Chokie attached
9th Bridge at Barah.
similar to that at Duggutpoor
with a 1st Class Chokie attached
10th Bridge at Muswanpoor
of 25 feet waterway in One arch
Roadway 15 feet wide - with Ghats Rajbuhs and Inlet Heads
11th Bridge at Khujoori.
built obliquely on an angle
of 37° has a waterway of
25 feet and a Roadway of
20 feet in width - a Rajbuhs
and Inlet head is appended
on the right - with a 2nd
Class Chokie -
12th Escapes at Duboroli, with
subpassages for the drainage
of the Duboroli Mulla - vide
1' Plate No XLII Atlas
13th Bridge at Duboroli
of 20 feet waterway and 18
feet Roadway - with Head
on the Right for the Rajmhow
and Tulempoor Irrigation
14th Bridge at Dilkapoor
of 20 feet waterway and
25 feet Roadway carrying
the Grand Trunk Road
across the Canal. -
15th Works at Baronpoor
No 1 Gunj Bridge
" 2 Do
" 3 Do

No 4. Guny Bridge
5. Do on Mogul Serai Bridge
6. Course Bridge
7. Bridge between No 1 and No 2 Locks

Plan

all these Bridges are on the same design as that at Duknapoor. and are connected together with Revetments. Ghats, Quays. Drainage Inlets &c along placed intermediately between each Bridge.

3 Locks of 9 feet each in descent. with Mills and Escapes.

Terminal works at the Rivers front.

Having passed in review the detail of Country, and works which have been constructed, on the line of the Caunpoor Branch from Narroon to the Ganges River at Caunpoor; I would here refer to Diagram XVII, Fig: II and to the division of Supply theoretically determined for the Branches at their departure at Narroon. It is better to retain the precise figures of this Diagram as by so doing the results will be more intelligible. and any excess or diminution in lengths to Channels which the actual working out of the project has shewn can easily be accounted for afterwards.

The actual head supply of the Caunpoor Branch which is estimated at 170 Miles in length is 1610 Cubic feet per second. the expenditure of this supply is calculated as follows:

an

an amount of 8 Cubic feet per second being allowed for each lineal mile of the Branch —

Miles Lineal	Cubic feet	Total	
170	× 8 =	1360	Cubic feet for Irri-gation as per rule laid down in Table
		50	Cubic feet additional for the purpose of giving supply to the Section of Country lying between the Essen and Cast Kalli Nuddi
		200	Cubic feet per second retained as surplus for the purposes of Navigation

I have in the detail above described figured the Transverse Sections of the Channel at different points on its course; the breadth (i.e. of the rectangular figure to which Slopes Equal to the depths of digging are given) is on leaving the Narroon Regulator 80 feet; this breadth is, on the next 100 Miles, gradually reduced to 40 feet; from thence to the 162nd Mile the width is reduced to 20 feet by a diminution of 1 foot in every 3 Miles until it arrives at the Muswanpoor Bridge: On this measurement it proceeds onwards to the Works at Cawnpoor —

The Capacities of the different Channels on the Sections above given are as follows: —

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91 to 90½ mile 1/5280
90 to 102 " 1/1000

Section at	Value of R	Value of 1/6	Sectional Area Sq: feet	V in feet	Discharge	
					Theoretical	Required
1st Mile	82	1/4224				
30th do						
65th do						
100th do						
135th do						
Dukinfield						

It will be observed by the above table that the slope of the bed varies; that in the early part of its course it continues at 1·25 feet per mile, and from that onwards it is diminished to 12 Inches per Mile. The change is an admitted evil, but from the profile of the surface of the Country, it was unavoidable; the outline of this surface has in fact led to the necessity of very inconvenient drops or sudden changes of level, by which means only we were able to retain within moderate limits the height of the Canal Embankments on the low tracts which occur in advance; - these drops interfere greatly with Navigation; they ~~just~~ lead to very nearly as much expense in lockage as the falls on the main Canal ~~have past us to~~, and they ~~have to~~ require ~~ments~~ for their passage by a Navigable Channel equal in extent to that of similar works on the main ~~Channel~~ trunk line. The first drop of this description which occurs on the Ashton branch is at the 3rd Mile at which

which point the Keyham proor Bridge is situated; on this Bridge flooring there is a fall of 2½ Inches, the advantages of which in taking up a lower line of levels for the Canal bed, will be duly appre-=ciated in considering the position which the Canal bed would have held with reference to the surface of the Country had such a de-=pression of bed not been carried into execution (see Atlas Plate V) At the 90th ~~Mile~~ and between that and the 102nd Mile, there is a similar depression equal to 2½ Inches, the difference of level being gained by an uniform addition of slope to the Canal bed lying between these two limits. it will be seen that the excess of level on such a long distance merely adds 2" p. Mile to the ori-=ginally projected slope of the bed, and as far as velocities of current are concerned lead to the following.—

Section at	Value of R	value of $\frac{1}{b}$	Sectional area Square feet	V in feet	Discharge	
					Theoretical	Required

93

We have however in the two cases above mentioned: One with a perpendicular drop, and the other with an inclined plane whose base is equal to 12 Miles; it will be interesting to observe the effects that

that the Current with its deposits will have in the region of these two depressions.. At the 71st Mile however a general reduction of the slope of the bed from 1·25 feet per Mile to 12 Inches leads to a still further departure from uniformity in the levels of the Canon por Branch, and tends in itself to produce a silting up, and a series of deposits at and in the neighborhood of that particular point where the diminution in slope commences The Canal bed in fact may be represented by the following diagram, shewing the varieties of slopes in an exaggerated degree.—

There can be no doubt that this irregularity, will, in the course of time be remedied, by a natural arrangement of deposits which will on the principle before explained, reduce the line to One uniform slope adapted to the particular regimen of the flow of water; and I hold so strong an opinion on this question, that (as I have explained when describing the works which are estimated for at the Keylum por Bridge) I have not deemed it necessary to go to the expense of building works for Lockage

Lockage, or for the convenience of navigation, trusting to the abrupt changes in the levels being obliterated by deposits.—

The difficulties arising from failures in Brick manufactories in procuring material generally, and, what was of equal inconvenience, of procuring laborers throughout the whole of the time that the Caumpoor Branch works have been in progress, were matters that reduced the Executive Officers in charge of the works to every shift that could be devised for ~~lessening~~ reducing both the Amount of labor and the demand for Material to a minimum; I have before explained that the soil in all the Centrical parts of this line of Canal, was not good for brick making; this evil, however, was in some measure remedied by the presence of Kunkur, which was procurable in great abundance, and in many places of excellent quality; Kunkur, therefore, not only took the place of Brick, wherever the failures in making the latter, had rendered such necessary, but it was used largely instead of Sookhi (pounded brick) in admixture with Lime.—

W. Allen

To reduce the expenditure of Material to the lowest possible limit, Lieutenant Hodgson the Executive Engineer found it convenient to carry on a ~~gradual~~ system

system of gradual reduction of waterway to the bridges corresponding with that ~~of the reduction~~ of the excavated Channel; by this much material was saved, although great additional work has been given to the Executive; It may appear strange, that either a saving in time or a saving in money can be contemplated in building a set of bridges whose waterway shall remain on a Maximum dimension; of building 10 Bridges of 50 feet waterway, instead of 10 Bridges ~~of~~ varying from 50 to 40 feet in width; but under the circumstances in which we are placed with regard to Establishment, and under our inability to obtain more than perhaps One or two good Mistrees (Head Bricklayers) in a line of 100 Miles, with European Supervision given at long detached intervals; there can, I believe, be no doubt that 10 Bridges built uniformly on one dimension without either variation in Plan or Elevation would be completed in a shorter time, and be built cheaper, more correctly, and better than were the plan and Elevation of every one different. — In quantity of Material however, the latter plan is an economical one, and it was for the saving ~~of Material~~ on this item that the Change from my original design was made. — The following list

List of Bridges with their waterways as explained in my Estimate of 1850, placed in juxtaposition with those actually built by Lieut Rodgson, will be explanatory of the changes that have taken place in this particular part of the Project.

Bridges divided into varieties, agreeably to Estimate of 1850.				Bridges built by Lt Rodgson			
Number of Bridges	Number of Bays	Width of each Bay	Total water way	Number of Bridges	Number of Bays	Width of each Bay	Total water way
9	3	33	99 ft	7	3	33	99 ft
5	3	30	90	1	3	32	96
7	3	26	78	1	3	31	93
5	2	33	66	2	3	30	90
12	2	30	60	2	3	29	87
7	2	25	50	3	3	28	84
9	1	30	30	2	3	27	81
8	1	25	25	3	3	26	78
				2	2	35	70
				2	2	33	66
				2	2	32	64
				2	2	31	62
				8	2	30	60
				11	2	25	50
				6	1	30	30
				2	1	25	25
				9	1	20	20

The design of the buildings is similar to that which has been used in the lower part of the Main Canal (vide Atlas Plate L) The main arches are flanked by towing path passages in prolongation of the berm and towing path of the Excavated channel. Irrigation or Rajbaha Outlets, are attached to every bridge with the few exceptions noted in the detail, and the Heads of these

these outlets which are situated immediately above the bridge, are protected by lines of Revetments and steps, the length of which depends upon circumstances; at common village Bridges, these Revetments are restricted to 60 feet in length; in the vicinity of Bridges connected with high Roads, with the main lines of cross communication, or with Escape heads, they are prolonged indefinitely, the maximum ~~length~~ depth, however, in no case exceeds 350 feet. In some cases Ghats have been built on the downstream side of Bridges, and as a general rule, the means of approaching the water have been given in every case, where by so doing the convenience of the people could be in any way increased.

The Escapes have been established as nearly as possible at a dis=tance of 40 miles apart, and in consequence of the insufficiency of the spannels for receiving the waste water of the Rinde have down to the 88th mile been ~~thrown into~~ expected with the Esun River. the Heads of the Works ~~themselves~~ are in all cases ~~connected with Bridges~~ stands on the up stream side of Bridges near which they are situated, and are on the plan represented in plate XXXIX of the Atlas. The sites of these works are at Ginnowli, ~~Bridges~~ into the Esun Nuggurea & Torea, and at the Kukiwan Bridge into the Pandoo River. The Dubowli outlet which passes its water into a tributary of the Pandoo, being considered as a component part of

Wittshier

of the Cawnpoor Terminal Works is not included in the above Enum=eration of Escape Channels.

I have explained when describing the Rajbaha Heads on the Main Line of Canal, the object that I had in retaining their Sills or floorings on a level higher than that of the bed of the Canal itself; the System has been put in practice throughout the whole line of the Cawnpoor Branch, by which means a cer=tain supply of water will be forced down to the lower Divisions. In the line extending from the foot of the Dasna Falls to the Nanoon Regulators this height of Sill has been uniformly main=tained at 24 Inches above the Canal bed; ~~the upper height has been continued in the Cawnpoor Branch a height of 24 Inches has been given~~ to the 30th Mile of the Cawnpoor Branch or to the Rajbaha Heads at the Guddunpoor Bridge; from this point as far down stream as the 90th Mile or to the Futtipoor Bridge the Sill has been reduced in height to 16 inches; From the 90th to the 150th Mile, or to the Runjeetpoor Bridge, the Sill has been reduced to 8 inches. From thence to the Canal terminus the Sills or floorings of the Irrigation Heads are on the same level as that of the Canal bed. Small as the supply may be that this arrangement insures to the lower divisions, it is a certain one; and one that cannot possibly

possibly be interfered with by the most extreme demand for irrigation in the upper Districts, in fact it is the only Method by which the Irrigation heads at the ~~extreme~~ tails of these long lines of Canal could meet with a certain supply: and the only device by which I could secure Irrigation to that section of Country lying between the Ganges and Pandoo Rivers, for which the Duboorli head, which is the terminal one on the Cawnpoor Branch is specifically built. —

In addition to the sill arrangements above noted, the widths of the Rajbaha heads and the consequent capacity for discharge has been reduced as the line of Canal advanced in its course, so that the relative discharge from these heads, might be in some degree proportioned to the decreased volume in the Canal itself: on this principle the 10 feet wide heads which from the head of Irrigation at Assoffnuggur continued throughout the Main line, cease at the 30th Mile, or at the Guddunpoor Bridge of the Cawnpoor Branch, from thence the heads are diminished to a width of 6 feet, on which dimension they are continued to the Duboorli Rajbaha head which is the last of the series. The Head at Duboorli however is

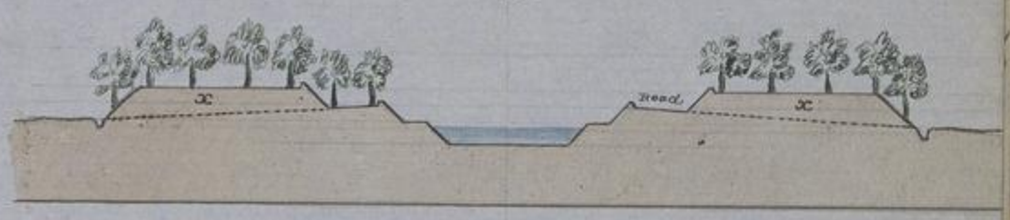
is, as I have before explained, constructed on a width of 10 feet with its Sill on a level with the Canal bed, so that the country which is dependent on that Head for its irrigation may derive every possible advantage from local circumstances.—

The design of the Channel with its berm or towing path, and its Embankments is very similar to that which has been executed on the Main Canal; the Towing Path is on the Cawnpoor Branch reduced to 8 feet in height from the Canal bed, to meet the decreased high water mark, and on that portion of the line which is connected with the works at Cawnpoor, or from the Dubowli Regulator, this height is again reduced to 6 feet, the towing path being with few exceptions maintained on a level parallel with that of the Canal bed; the exceptions to which I refer, are when the digging is unusually deep in which case, the towing path has a gradual rise, and is adapted to the profile of the country, but on such moderate and uniform slopes, that the absence of the parallelism before alluded to is neither inconvenient, nor is it a disfigurement to the general appearance of the Section.—

The road which is con-
structed and designed on the
same

same Principle as that which has conducted us down to + Nanoor; is continued along the Cawnpoor Branch on the left bank ~~down~~ to the Terminus on the Ganges. The width be=tween the boundaries, however, is in some places too narow to admit of the earth which is excavated from the Channel being Spread out on one + uniform, and at the same time moderate height. In these cases therefore, the Superfluous earth has been formed into an elevated platform in rear of the Roadway, the Section of the Canal under these circumstances being as follows: -

Diag: XLII



x. x. Shewing the position in which the Superfluous earth is placed. The Roadway on this Section is limited to a width of 20 feet clear of the edging or Small ridge of earth which is carried along the Top of the in=terior Slope, has a slight slope to the rear, and the rain water is carried off to the boundary ditches by Channels which are made through the raised platform x at distances of 500 feet apart; the facility of procuring Kunkur will enable these drains to be protected from wear, and the

outer

outer ditches will carry away the water to the Inlets which are built at each bridge in con=nection with the Rajbaha Head Channel.-

Mile Stones on the same plan as that before described and placed in the same relative positions to the roadway are continued from Nanoor to the Cawnpoor Terminus; they are numbered from the Nanoor Regulator downwards in one continued series; these Mile Stones act as Benchmarks, and are intended to have the precise level from the flooring of the Myapoor Regulator at the Canal Head, engraved upon them. The Plantations are throughout this branch similar in every respect to those on the Main Canal; the Species of Forest tree is con=fined as far as possible to that which is indigenous to the Dis=trict through which the excavation is carried; in those parts where the Kekur (Acacia Arabica) grows more luxuriantly than other trees, the Kekur is selected as the staple wood for the plantation; where the Neem (Melia Azadirachta) thrives with greater luxuriance, the Neem has been selected, and by these means, a more rapid, and a more certain growth to the Trees in the Plantations have been secured. In all cases however, the line of mangoe

Trees

Trees to which I have before advert=ed, as likely to be of such great benefit to the Roadway in pro=viding shade, and of such great ornament to the banks from its size and extent of foliage, is maintained as a part of the plantations.—

The accommodation for the Establishments and for the Chain of Station posts, is of the same scale as that on the main line, viz: 1st Class Chokis buildings at distances of about 12 miles apart, with 2nd Class Chokies at each of the intermediate Bridges; the plan of these build=ings is given in Plates LIV & LV of the Atlas.— The design of all these Chokies is uniform as well as the position in which they are placed relatively to the Bridges and the line of Canal: Deviations from this uniformity have occurred in two instances: the Baboi 1st Class Choki having been built on a mound at some distance from the left bank, and that at Barah having been placed on the Right bank of the Canal, at a distance from the Bridge, and in a situation somewhat inconvenient for ~~the~~ the pur=poses ~~for which it was intended~~; so inconvenient do I consider the position of this Choki building, that in preference to continuing its repair and maintenance, I would recommend that another

Choki

Choki be built near the Barah
Bridge and on the site that was
originally intended for it. At
each of the 1st Class Chokies a Mangoe
Graft plantation will hereafter be
established, on the same plan
as has been adopted on the Main
line, and on the same scale, as
has been so successfully carried
out on the Eastern Jumna Canal

The works on the Cawnpoor
Branch, were up to the 31st August 1832
separated into Two portions, which
went under the titles of the 4th Two
and 6th Divisions. Lieut Hodgson
of the Engineers holding the Ex-
=ecutive Control of that portion
extending from Narroon to Sooreya
equal in length to 100 Miles: and
Lieut C.W. Hutchinson of the
Engineers having the Supervision
of the remaining 70 Miles in-
=cluding the Works at Cawnpoor
On the 1st September and 6th December 1832
Lieut Hutchinson and his Assistant
resigned their situations, and pro-
=ceeded on Medical Certificate to
England and New South Wales
leaving the Works without any
Engineer Supervision whatever.
the
Opportunity, therefore, was taken
to break up the 6th Division,
the existence of which in such a
limited form was perfectly acci-
=dental, and to Place the whole
of the Cawnpoor Branch under
Lieut Hodgson's control. The
Works, therefore, of the Cawnpoor
Branch have, since the Month
of September 1832, been carried on

by

~~that~~ Officer
by ~~Lieut Bodyson~~, who, aided
by Lieut Lamb of the Regiment
of Artillery, and by Lieut E:-
Willoughby of the same Corps
(the latter ~~Officer~~ having been ~~al-~~
~~-lowed to aid Lieut Bodyson~~ placed in charge of
~~in~~ the works at Cawnpoor, retaining
his Regimental duties) has brought
the works to a state of completion
that I had at one time hardly
anticipated; Lieut. Bodyson's
success under very great difficulties
has been highly satisfactory;
and although the completion
of the works at the Terminus
~~at Cawnpoor~~ by the time that
the Canal is opened will not
crown his efforts, the works them-
-selves will be as far advanced,
as circumstances would admit
of under a demand for bricks
which far exceeded the supply
procurable from the Brick Manu-
-factories. The difficulties of
procuring bricks at Cawnpoor
as elsewhere, however, have
depended in a great measure
on failures in brick burning,
a misfortune before alluded to
and which was in all probability
quite unavoidable. —

W. Cullen

The Etawah Terminal Line ~~Branch~~

The total length of this
Branch from the Nahoon Regula-
-tor to the Terminus on the
Jumna is 175 Miles. It leaves
the Regulator at an angle of
21½ degrees corresponding with
that

that of the departure of the Cawnpoor Branch, and after pas-
=sing the Ford of Bijigurh at which it takes a Sweep, bringing it in direct parallelism with its Sister branch, and with the course of the Rinde River, it proceeds onwards ~~in the same direction on the parallel course~~ on a length of 65 miles; at this point ~~and~~ at the village of Gungsi, it makes a turn to the right, leaving the Rinde and keeping ~~close to~~ the heads of the Ahnera and Phoora, two Rivers which join the Rinde in one connected channel under the village of Bhimwanmow. ~~Keeping clear of~~ the drainage connected with the above two Rivers, the line ~~of Branch~~ regains its parallel ~~direction~~ to the Rinde which it maintains from the 116th to the 115th Mile: At this point a comparatively sharp turn to the right near the village of Gujchmow, not far from the Town of Ukburpoor, clears the heads of the Noon, a River that rising near Ukburpoor takes a course ~~nearly~~ almost parallel to the Rinde. From thence the Canal ~~keeping~~ passing to the right of the Noon, reaches the Jumna River at the village of Futtiabad, 8 Miles east of the Town of Moosanuggur.—

Sig Y: P. 321—

From the above general description it will be understood that the Etawah ~~Branch~~ Termini &c, through-

=out

=out its whole course runs to the right of the Rinde River, keeping as much as possible out of the influence of the tribu=taries and drainage which are connected with it. ~~On its right~~ The Seyngoor River, the heads of which lie in the neigh=borhood of Koel and the Town of Bijigurh, throughout its whole course, maintains a parallel ~~direction~~ flowing on its right to the Canal, so that in fact the Otawah Branch from its head at the Nanoor Regulator to its Terminus in the Dumna, passes between the Rinde and the Seyngoor Rivers on a course as equidistantly marked out, as the position of the ridge or watershed would admit of.—

The line upon which these works are carried was only touched upon by me in my original Surveys in a series of levels which was carried to the South of the Town of Koel, and which in an on=ward course by the Forts of Bijegurh, Deori and Ava, terminated at the Town of Gihror, from whence it crossed the Rinde at the Village of Dirba, to Nohnein and the East Kalli Nuddi as con=nected with the Branch which now runs to Cawnpoor My Surveys, therefore, with the exception of fixing certain points of level, were of no practi=cal importance.

In the Cold Season of 1815/16

1845/46 Mr Dodsworth the Sur-
-veyor of the Ganges Canal works,
was deputed to report upon the
Country lying between the Rinde
and the Jumna Rivers. He was
directed to commence from a fixed
point or Bench mark which I
had established on a Tomb at
the Village of Umunpoor, near Koel;
from this Bench mark a series
of cross sections was to be taken
at every 5 miles keeping the
Rinde as the left and the Jumna
as the right boundary, and
upon this series of cross sections
he was to Establish a longitudinal
line of levels, so as to determine
as closely as possible the Water
Shed between the Rinde and
Seyngoor

Mr Dodsworth's Surveys
were completed in the Cold weather
of 1847/48 they had been carried
out in the fullest detail as far
as Instrumental work was con-
-cerned; and the information
which they conveyed enabled me
to frame a very accurate Estimate
of the line upon which a branch
for Irigation ought to be carried

With Mr Dodsworth's Maps
in hand, Lieut Whiting of the
Engineers, who was appointed
to the Executive charge of the
Etawah Branch, denominated
the 5th Division, commenced
his Surveys in the Cold weather
of 1849/50. these Surveys inde-
-pendently of verifying the
results of Mr Dodsworth's levels
placed upon paper the whole of

the

the drainage between the Rinde and the Seyngoor in all its intricacies and ramifications; exhibited the position of the dif=ferent Wheels and hollows form=ing the heads of the tributaries and the lines connecting them with the above Rivers; and traced out a ~~line~~ course for the Canal, which maintaining itself on a fair and regular alignement, runs as closely as possible on the watershed. —

This close examination into the minute detail of the cross drainage of the Country, led to some deviations from the line which had been marked out in Mr Dodsworth's Map, and it was found convenient from the exceeding intricacy of the drainage at the Head of the Noon River, and the great extent of flats and hollows lying on the Country over which it takes its course, to leave this River altogether on the left of the line of the Canal, thereby deserting the tract of Country situated between the Noon and the Rinde upon which the Towns of Dar and Ghatumpoor are situated. The Canal therefore passes through the westerly por=tion of the Ghatumpoor Pur=gunna, or that lying on the right of the Noon; leaving the Easterly portion, or that bounded by the Rinde, Gunna and Noon, to be irrigated by Rajbuhas by which it is both approachable from

from the bridges above Ukburpoor, by turning the heads of the Noon, and more directly, by lines of water course carried over the valley of the Noon river.—

It will be understood from what I have written in the early part of this Chapter, that the Surveys of this ~~part~~ fact of Country were completed previously to ~~Commenced at the~~ the commencement of ~~Head Quarters with~~ those of the ~~Main & Canapoor Terminal Lines~~ Districts, South of Meerut. An Engineer Officer however was not appointed until late in the year 1819, and it was not until the Cold weather of 1820/21 that ground was broken, and that a commencement was made in Bridge and Choki building The 3rd 4th and 6th Divisions, or those including the last 70 Miles of the Main Canal, and the Canapoor Branch, were, therefore, at this Period, 2 years in advance of the 5th or of the Etawah Division, a circumstance that will account for their advanced state of progress at the period when I left the works—

I shall now bring under review the works and the Country over which they pass, in a detail similar to that which has been followed on the Canapoor Branch; commencing with the first thirty Miles, or those which lie between the Head at Nanoor Regulator, and the Bridge situated opposite the Town and Ford of Anoo.—

In

In describing the course of the Cawnpoor Terminal Line on its leaving the Nanoon Regulators, I have in some measure explained the peculiarities of the Slopes of the Country at that particular point, its connection with the heads of a very extensive system of drainage, and the cause which led to the Nanoon Station being fixed upon as that ~~best~~ best adapted for the site of the Heads. It will be unnecessary therefore to ~~enter upon~~ advert to the drainage of the Rinde River, the marked and main heads of which clearly lie to the North of Nanoon itself; further than to draw attention to a tract of Country lying around the Village of Tsabalii, which is so closely connected with ~~both~~ the drainage both of the Rinde and ~~that~~ that of the Teyngoor, that not even the levelling Instrument, nor the most detailed and determined examination of its Profile could lead Lieut. Whiting or myself to any further conclusion than that the drainage was common to both Rivers; there was the slightest possible tendency in excess of Slope towards the Rinde; to the Rinde, therefore, the Tsabalii drainage has been consigned, and the line of Canal on its leaving the Regulator at Nanoon, passes to the west of that Village; separating its drainage entirely from that of the Teyngoor. I have no

doubt

doubt that the determination of the alignement will prove to be correct, and that the hollows about Swaballi will pass off their superabundance of flood water to the Rinde - The following Diagram, however, will place the topographical features of this part of the Country still more distinctly before the reader; it gives both the Cawnpoor and Etawah lines, as they are connected at Nanoon with the drainage of the Rinde and Seyngoor Rivers

The three points A B and C were those from among which we had to select the best adapted for the head of the Terminal lines; and the election fell on that which was centrically situated as having the two fold recommendation of being well suited for the site of the necessary buildings & admitting at the same time our giving favorable directions to the Terminal lines themselves, the best adapted for

~~for the purposes required~~: the
election in fact lay between the
heads marked B and C; as that
from the point A would have
drawn the Canal in contact with
the hollows and flats in the region
of the Bijigurh fort. Between the
positions of B and C as sites for
public buildings there could be
no question that the preference should be given to B ~~was the preferable one~~; and as the results of our
levelling operations had shewn
~~sufficiently~~ clearly that the Swab alli
drainage was connected with the
Rinde, there could be no doubt
that preferable as it was as a site
for a public station, it was still
more so as that for the heads of
the Terminal lines, which by being
separated at this point would
have the least possible connection
with the Cross drainage of the
Two rivers

The Etawah Terminal line
therefore, passes Swaballi to the
west, and proceeds onwards touch
-ing the heads of some drainage
connected with the Seymgoor
in the neighborhood of the Fort
of Bijigurh: the contact is very
slight, ~~it occurs~~ occurring at the 4½ mile
near Bujrungpoor and at the
5½ mile near the village of
Doopoor; the country is ex-
-ceedingly flat throughout,
so much so that on the right of
the Canal, as it passes by the
Fort of Bijigurh which lies at
a distance of half a mile, the
eye

eye wanders over sheets of ~~waste~~ waste
and uncultivated plain, the
whole of which throws its
drainage into the Seyngoor
River - As far as the Fort of
Bijigurh the line of Canal is
carried on a bearing almost due
South, from thence, however, it
takes a turn to the left proceed-
-ing onwards in a Southeasterly
direction running parallel to
the Rinde as well as to the
Caverypoor Terminal line; at the
10th Mile the Canal comes in
contact with a hollow in the
neighborhood of the Village of
Dao, over which it passes under
the inconvenience of heavy em-
-bankments, but with little
interference with drainage; at
the 12th Mile, another hollow but
small, ~~cross~~ as compared ~~relatively Speaking~~,
with that at Dao, is crossed
under similar circumstances;
the Canal, in fact, at the above
two points is purging ~~the~~ a
line of drainage that passes
into the Seyngoor under the
Town of Dulysur - On its
onward course, and between
the 17th and 23rd Miles, or between
the Villages of Soreyra and
Roodanpoor, the Canal crosses
the heads of a third line of
hollows which ~~is~~ are also con-
-nected with the Dulysur
Nulla - Opposite the Village
of Pilkutra which lies on the
right of the line these hollows
extend to a distance of about a
Mile

Mile and as far as the Village of Gadri which lies equidistantly between the Canal and the Rinde River:- the whole of this series consists of straggling lines of low ground, which appear to be connected with Sheels or deep ponds lying under Pilkutra and the Village of Nooh, the latter hollow being again connected with ~~another series~~ of drainage which passes off to the Seyngoor, by the Towns of Mustafabad and Jushana ~~which are situated~~ considerably to the East and opposite the 40th and 50th Miles of the course of the Canal. The portion of the low land however which is thus cut off from the drainage leading to the Seyngoor, will by artificial cuts be connected with the Course of the Rinde, and by these means be as effectively drained as they would be otherwise. From Pilkutra the line turns slightly to the left sweeping round by the Villages of Keyrna and Lukana between which it passes to the Village of Soonain, from whence it continues on a bearing similar to that on which it arrived at Pilkutra; the sweep above alluded to, enables the Canal to pass the heads of the Seyngoor drainage which run up to the Fort of Awa, and its neighborhood, and it passes between this and the Kureyra and

Muhobutpoor

Muhobut poor hollows which
fall into the Rinde, with the
slightest possible interference
with the slope of either of the
Rivers; the watershed is in fact
most closely followed on all
this line, and with the exception
of an intersected portion of low
land connected with the Seyn=
=goor, which lies between the
29th and 31½ miles immediately
on the approach to Soonari,
the Canal passes over high land,
more or less cultivated; the portion
of hollow which has been thus
cut off will it is supposed
be relieved by a Cut into the Rinde
which lies within a distance of
a mile or a mile and a half
from it; it is naturally connected
with a system of drainage which
stretches over the Country between
Awa and the Canal, and which
passes off to the Seyngoor by
the Mustafabad line of nullas
before alluded to. —

The width of Country be=
=tween the Rinde and Seyngoor
upon which the Canal takes its
course, expands as it approaches
the Ford of Awa; on its leaving
Nanoon and at the Bijigunj
Fort and Gunj the distance be=
=tween the two Rivers does not
exceed 5 Miles, at the 30th
Mile and on a Cross section
at Awa, the distance has in=
=creased to 12½; the watershed
lies close upon the right bank

of

of the Rinde upon which the Canal runs, at a distance of about 2½ Miles from that River The slope of the Surface of the Country from Nanoor to the village of Soonaii, or to the 30th Mile, is 44·86 feet averaging 1·49 feet per Mile, and the relative position of the beds of the Rinde and Seyngoor to each other will be understood from the following table. This table has been deduced from the Sheets of levels taken by Mr Dodsworth, and as it includes the Kunoor, (a River with which the Main Canal runs in connection, in its passage through the Bolund-Shahee District) and the Jumna River at the points where the Kunoor joins it, the relative levels of each will be interesting

	Below the Rinde River							
	Mudsore	Seyngoor Bed	Kudgaon	Eyta	Augwar	Chuberpur on Edge of Jumna	Kunoor	Jumna
	ft	ft	ft	ft	ft	ft	ft	ft
Across Section East of Bijigurh ½ 10th mile	—	3·36	—	—	—	—	—	—
Do Bussayn 15th mile	—	5·66	—	—	—	—	22·0	—
Do Patna 20th mile	—	7·70	—	—	—	—	35·25	—
Do Nooh and Suleysur ½ 25th mile	—	5·09	—	—	—	—	44·05	—
Do Awa 30th mile	0·51	7·58	above 1·70	above 5·65	above 0·94	4·15	71·3 Sandstone of	71·3

With reference to the last Section I may observe that Mr Dodsworth appears to have taken the low line of Nulla and Expanse of flat lying on the immediate North of the Fort of Awa, as the Rinde

Rinde River whereas this nulla
and these shallows are in fact
as I have before shewn, the head
of a line which runs by the
Town of Mustafabad into the
Seyngoor. Lieut. Whitings
levels taken on a cross section
between the Awa hollows and
the Rinde, (the distance being
2¼ Miles) give the following
results, using the figures of Lt
Whitings Series: The site of
Lieut. Whiting's Station at Awa
must have been close upon that
which was taken up by Mr
Dodsworth

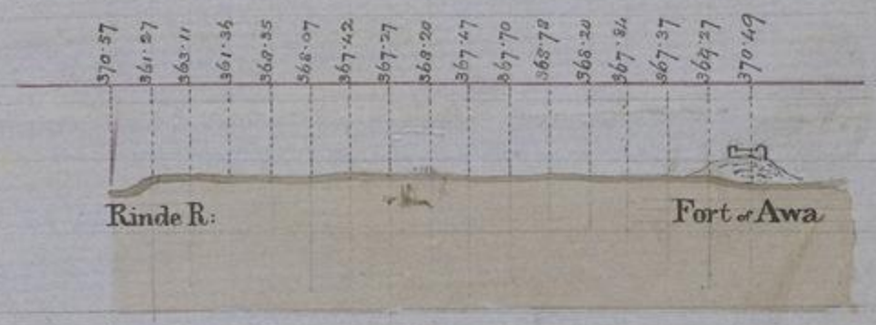
Awa station 370·49
Brd of Rinde 370·57

and the results as shewing that
there is only a difference of 00·08
is curious; it is very characteristic
however, of the profile of the
Country connected with the
heads of these Rivers, and of the
difficulties that attend upon
Canal Engineering when ~~it is~~ they
~~brought in contact with them~~ have to be dealt with.
Nothing could have been more
natural than the error into which
Mr Dodsworth fell, and it is pos-
-sible that had he extended his
cross section, in prolongation of
the line upon which he was
working, and had come upon
the Rinde itself, he would have
considered that he had come
in contact with the Essen River.
The profile of the country
lying between the Awa hollow
and the Rinde, and a cross

which

~~section~~ which the line of Canal passes, is shewn in the following Diagram.—

Diag: XLIV



The point at which Mr. Dodsworths Cross Section on Awa meets the Jumna River at its junction with the Kurson Rivers is about 2½ Miles below the Taj at Agra, ~~and at the junction of the Kurson River with it~~; the levels shew the Surface of the Water of the Jumna in the month of December ~~—~~ Appended to the levels of the different points immediately connected with the beds of the Rivers, ~~I have added to this section in the Table the relative levels of different~~ are those of the villages with which the Cross section came in contact; throughout the whole line between the Rinde and the Jumna, the maximum difference of Surface does not exceed 6 feet and that only in very short distances.—

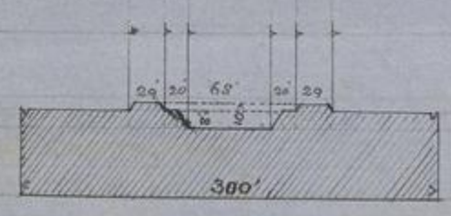
It will be observed from the Table above given, that the course of the Rinde is on a higher level than that of the Seyngoor, which runs relatively to the Rinde much in the same way that the Cesun does as described in a former paragraph. The beds of the Seyngoor however as it will be understood from what has gone before, take their rise

rise on a Country situated on higher levels than that of the Rinde ~~canal~~ in the same way as ~~was the case with the Rinde and~~ those of the Rinde rise on a higher level than those of the Cesun Rivers

The Section of the Canal Channel at the 30½ Mile is as follows:-

Diag: XLV.

Section at the 30th mile



the width of the rectangular section having been reduced in the 30 miles, from 80. which was that upon which the excavation is commenced, to 68 feet

The Slopes of the Canal bed are on one uniform ~~base~~ series of 15 inches per Mile

The rule with regard to minimum dimensions is maintained here as elsewhere, that of the height of the berm or towing path being 8 feet from the Canal bed and that of the top of the Embankment 10 feet.

The average depth to which digging has been carried on the above line is as follows:-

From the 1st to the 10th Mile 6·30 feet
10th " 20th " 8·97 "
20th " 30½ " 7·13

The Soil is good and tenacious, and occasionally mixed with Kunkur, the Alkali to which I have referred as existing in such large quantities, and

over

over such extensive surfaces in the Mynpoori District, is prevalent; particularly so, on the plains in the neighborhood of Bijigurh and Awa; in other respects the soil appears favourable to be of a non absorbent quality, and therefore well adapted to the retention of water.

Garnett

The depth of wells on a measurement from the surface of the Earth to the surface of the water is on the

Left of the Canal Line		Right of the Canal Line	
Maximum	29 Feet.	Maximum	78 Feet
Minimum	13 "	Minimum	15 "

The following Works have been constructed on the above section of the Etawah Terminal

1st Bridge at Chitrowli 3 arches of 33 feet each, 18 feet Roadway - with Ghats, Rajbaha and Inlet heads, and a 2nd Class Choki attached. -

2nd Bridge at Bijrungpoor similar to that at Chitrowli with a 2nd Class Choki attached

3rd Bridge at Bijigurh similar to that at Chitrowli with a 2nd Class Choki attached

4th Bridge at Jao - 3 arches of 30 feet each - 18 feet roadway with Ghats, Rajbaha and Inlet Heads, and a 1st Class Choki attached. -

5th Bridge at Lodhipoor similar to that at Jao - with a 2nd Class Choki attached

6th Bridge at Kutai - similar to that at Jao - with a 2nd Class Choki attached

7th Bridge at Seetapoor similar to that at Jao - with a 2nd Class Choki attached

8th

8th Bridge at Pilkutra similar to that at Dao - with a 1st Class Choki attached -

9th Bridge at Nooh - simi- -ilar to that at Dao - with a second Class Choki attached

10th Bridge at Doeyri - similar to that at Dao, with a second class Choki attached -

11th Bridge at Guhrana 3 arches of 30 feet each - 18 feet Road- -way -

12th Bridge at Soonari - 3 Arches of 26 feet each - 18 feet roda- -way - Ghats Rajbuba & Inletheads and a 2nd Class Choki attached

From the 30th we continue our course as far as the 65th mile or to the Village of Gangsi at which the Canal changes its direction to the right, and dis- -continues its parallism as well as its propinquity to the Cawnpoor Branch. —

30th to 65th Mile

The direction of the course of the Canal on its leaving the Soonari bridge is South East, and it reaches Gangsi by a gentle curve, on a bearing al- -most due East; it keeps to the high land near the Rinde, to which it runs parallel and at a distance of about 2 Miles

The width of Country between the Rinde and Seyngoor is at Soonari 12½ Miles, in the neighborhood of Gangsi and Dirba, or at the 65th mile this width has gradually diminished

to

to 5 Miles, the drainage towards the Seyngoor running in many places close up to the edge of the Rinde, ~~close upon~~ adjoining the right of which is the watershed.

I may here observe that from the Nanoon Regulator the Cawnpoor and Etawah terminal lines run parallel to each other as far as the 65th mile at which point they separate, the one passing off to the Futtigurh and Cawnpoor Districts, the other ~~proceeding~~ going on towards Etawah. On these 65 Miles of their course their maximum distance from each other is 5½ Miles; their minimum distance is 4÷ at the point of departure near Ganysli they are 4¾ Miles apart. The Rinde River runs equidistantly ~~between~~ although on its own straggling course between them. On this line therefore, the drainage of the River is directly limited by the Canal works to a basin which on the measurements above given equals 65 Miles in length on an average width of 4¾ Miles, or to a superficial area of 308¾ Square Miles; both the branches of the canal however run so closely upon the natural watershed of the Rinde that with the exception of that portion extending to the North of Nanoon, and lying on the left of the Cawnpoor terminal line, the natural boundaries of the basin, and the artificial ones now given by the two lines of Canal, may be considered as

as sufficiently coincident to
enable us to determine the
actual volume of flood water
that may be expected to pass
at the village of Dimba, there
is no necessity for entering upon
the question here, but it is one
that may ~~hereafter~~ be of im=
=portance when estimating hereafter
the value of this flood water, as
convertible to useful and econom
=ical purposes. ~~to which a short~~
=~~space will be made hereafter.~~

In taking up the details
of the Country over which the
Canal passes, and on leaving
the Toonari Bridge, the drainage
towards the Seyngoor, which
I have described as rising in
the neighborhood of Aiva, runs
on the right and parallel to
the Canal, at a distance of
about 2½ Miles, until it
reaches the 41st Mile, or the
village of Peydhut, which
lies 2¾ Miles due North of the
Town of Mustafabad under
which the drainage in question
passes off by Drisrana to the
Seyngoor. At two points only
viz^t at the 36th and 37½ Miles
of the course of the Canal, the
works come in direct contact
with cross drainage, the first
near the village of Kuttana,
where a hollow of no importance
~~and which is~~ connected with
the Rinde is crossed, the second
near the village of Deywa from
which onwards as far as Peydhut
the Canal line pinges a suc=
=cession

=cession of shallow depressions which are connected with a large sheet that lies to the South of that village, and which is on the slope of the Seymgoor River; with these two exceptions the Canal from the 30th to the 41st Mile passes over land tolerably well cultivated and altogether free from marked drainage. A cross section taken from the Ridge to the branch of the Seym=goor under the town of Mustafabad and passing by the village of Peydhut, shews that the Ridge at this point is

2·01 feet below the Mustafabad hollow
6·86 " below the Peydhut hollow
10·83 " below the surface of the ground over which the Canal passes

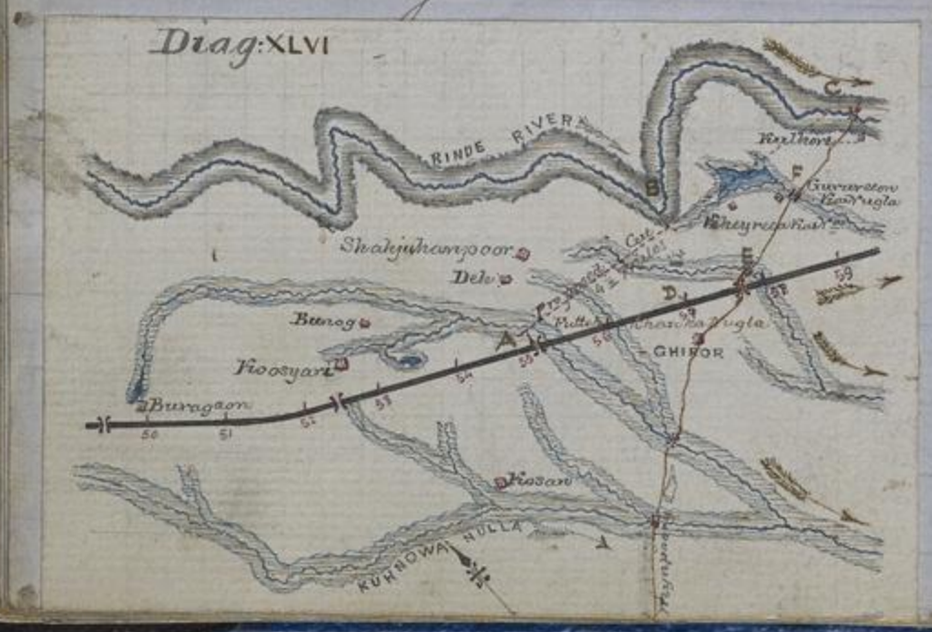
From the 41st Mile the Canal continues uninterruptedly passing close by the villages of Puteekra, Burragaon (at which there is a Tower denoting one of the station points of the Meridional Series of Colonel Everest's measurement of the great arc) Kookyari, all of which are on the left of the line until it reaches the village of Futteh Khan ka Nugla at the 55th Mile; at this point, as well as at the 56th Mile, the Canal crosses drainage which uniting with the Kuhnowa Nulla joins the Seymgoor at Kunukpoor; at the 58th Mile also it crosses drainage which ~~two others in advance which are situated at the 56th and 58th Miles, the lines of Canal cross drainage which unite the name of the Kuhnowa Nulla~~, joins the ~~same~~ River between the two villages of Dsmailpoor and Nibbipoor

No 1

No 1 line, or that which is intersected by the Canal at the 55th Mile rises in the vicinity of the village of Burragaon, it extends for about 2 Miles to the left of the Canal, collecting in its course (which may be estimated at 6 Miles in length) the drainage from the country in the neighborhood of Birnog, Koosyari, and crossing the Canal at the village of Futtu Khan ka Dugla

No 2 line, or that at the 56th Mile, rises in the vicinity of Shahjuhanpoor and Deh, 2 villages situated at 1¾ Miles from the point where the Canal intersects it.—

No 3 line, or that at the 58th Mile, rises in the same part of the Country as that last described: its course before it reaches the Canal is 3 Miles in length. The value of the drainage here may be estimated by the waterway of a drain connected with the Grand Trunk Road which crosses it, close to the Ghiror Bridge ~~which is built~~ at the 58th mile; the width of this waterway is 3 feet. The following Diagram will make the above description more intelligible. —



Agreeably to the figures of the Whitings Series, the levels of the different points notes above are as follows:-

A	398·63
B	401·94
C	405·85
D	399·17
E	399·55
F	399·09

A Cut made from A to the Rinde River at C will have a total fall of 398·63 – 405·85 or 7·22 feet, or as the length of Cut is 4½ Miles, the slope of the bed will be equal to 1·6 feet per Mile, it is proposed to make the Channel 15 feet wide, so as to give a free and unimpeded passage and it is hoped that by these means, the ~~line of~~ County ~~Drainage~~ from Burragaon along the left bank of the Canal will be fully relieved. At the 61st Mile the ~~line of~~ drainage marked by the letter F in the above Diagram crosses the Canal in connection with another Tributary of the Seyngoor which joins that River near the village of Utta: the head of this line, which I call the Utta River, appears to consist of a large Wheel under the two villages of Kheyrea and Gurreeon Ka Nugla, and situated on the west and between the Grand Trunk Road and the Rinde From the Kheyrea Wheel to the point where the Canal intersects the drainage at the 61st Mile, the distance is 3½ Miles; a second Cut will be required

to

to carry away the water of this line to the River. From the 61st Mile, the line of Canal by sweeping round to the left escapes three extensive hollows or Jheels, viz': those of Bidhowna, Oodhunna and Soj, all of which with a network of drainage are left in open communicating with the Seyngoor, which they join in one connected valley under the Village of Seypah The Canal just touches upon low ground connected with this drainage to the North of Bidhowna, as well as to the North of the Village of Gangsi, but the interference is of a nature offering no impediment either to the works or to the Country.-

At the Gihor Station and attached to the Bridge over which the high road between Mynpoori and Agra crosses, is an Outlet into the Seyngoor; it consists of a waterway of 30 feet, divided into 5 bays of 6 feet each,- the work forms a component part of the bridge buildings, and is connected to the Bridge by a line of Ghats (Atlas Plate XLV).- The distance between the Canal at the Escape and the Seyngoor River is 1 3/4 miles and the difference of level between the Sill of the Sluice openings and the bed of the River is equal to 10·17 or 2·9 feet per Mile, the excavated Channel being 25 feet in width Between the Gihor Bridge and the

S. 9 Z - P. 337

the 65th Mile the Raybuha heads attached to the Bridges on the left Embankment will in all probability be connected with a main line of irrigation which will be divided into 2 Branches, one for the purpose of irrigating the Country between the Rinds and the Phoora Rivers, and the other for the irrigation of a similarly situated, although smaller, tract lying between the Phoora and Akneea; to this however, I shall refer more explicitly hereafter.-

The slope of the surface of the country from the 30th to the 65th Mile is equal to 38·18 or on an average 1·09 feet per Mile On this section we come on contact with a sudden change in the level of the Country which appears to me to be one of the characteristic and marked features of this Doab, when approaching the heads of an extensive system of drainage; I have adverted to this change of slope elsewhere, especially when describing the Country in the neighborhood of Alligunj and Koel, at and near where the Rinde, Seyngoor, and Cesun take their Origin; it is marked in the line of Canal by the Simra and Pulra Falls, by which the sudden variation of level is overcome by descents of five feet each, and at the Keylunpoor Bridge it is represented by a

H. Allen

drop

drop of 2 feet: the Surveyor in fact in his progress with the levelling Instrument finds that he has suddenly made a descent, and that the Profile runs entirely upon a new and different series.* In a general aspect the Country lying between the Ganges and Dumna has a surface with varied slopes diminishing as it approaches the junction of the two Rivers at Allahabad; it is separated into series of well defined and sudden changes of levels, giving the profile an appearance of Steppes each of which is marked by its own peculiar drainage, and each of which defines, in a manner the most unmistakeable, the position of the watershed. —

At

---

*This complete change in the series of level to which I have adverted in the text, must not be confounded with local depressions which are occasionally met with under circumstances which are very liable to mislead. A good example of local depressions extending over very ~~extended~~ wide surfaces is shewn on the track of country ~~stretching~~ between the Dumna and Ganges near the Town of Futtipoor: on the approach to which and in the space of 2 Miles my levels ~~gave~~ shewed a depression of 8·63 ft, with an unusual continued fall of country for five miles in advance, on the 6th mile however a rise took place which restored the Amount of fall to the original series on which the Profile had existed previously to reaching the low land near Futtipoor: the following table shewing the amount of depression at each mile will exemplify the interruption in the uniformity of slope, caused by the 6 Miles of hollow above alluded to. From the 360th to the 382 mile or at a point close to the Town of Futtipoor, the slope was 16·43 ft or 0"7·46 feet per mile. From the 390th or from the point where the hollow terminates the slope continues at about 12 inches per mile which in calculating the levels from the 360th to the 410th mile will be found to be the true average of the slope of the Country

360th	Mile.	526·59 ft	from the Zero Point of my levels at Sundowa
382	"	543·00	
383	"	547·88	Sudden fall of 4·88 as Hollow 3·75
384	"	551·63	
385	"	553·08	
386	"	555·08	
387	"	558·76	
388	"	565·58	
389	"	550·74	level regained at 1 foot per mile
390	"	562·80	
400	"	563·90	
410	"	573·85	

At the 49th Mile, and on the approach of the course of the Canal to Burragan, the Surface of the Country which has been continuing on a steady slope of about 1 foot per Mile, abruptly takes up a level 4 feet lower and proceeds ~~towards~~ in advance on a slope similar to that ~~at~~ with which it arrives at the crest of the drop: this sudden variation will be best understood by a series of figures which represent the depression of the Surface at each Mile below the Zero point of Lieut Whitings levels

From the 39th to the 49th Mile the slope of the Surface of the Country is 9·02 feet or ·902 per Mile. thus

39th Mile	378·13
49th "	387·15
50th "	391·21
60th "	403·05

and the abrupt drop of 4 feet that occurs on the line between the 49th and 50th Miles is not again recovered: from the 50th to the 60th Mile the Country proceeds on an equable slope, on which it continues. Here the slope of the Canal bed is reduced from 15 to 12 Inches per Mile, upon which ~~slope~~ it is carried to the Summa: this change of slope occurs at the 52d Mile

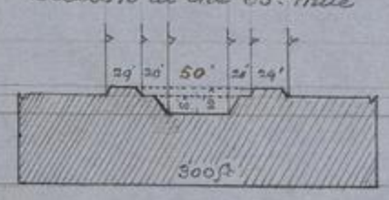
The relative positions of the beds of the Rivers deduced from Cross Sections taken by Mr Dodsworth shew the high course that the Rinde maintains over all the Rivers lying on its right

		Below the Rinde		
		Seringoor	Sirda	Summu
		Feet	Feet	Feet
	35th mile	5·35	–	76·75
	40th "	3·66	7·57	77·62
Ferozabad	45th "	2·14	3·00	79·68
Sursawa	50th "	4·01	1·66	83·75
	55th "	7·33	2·16	83·40
Kulhee	60th "	7·96	3·25	92·84
	65th "	12·63	4·45	94·56

The Section of the Canal Channel at the 65th Mile is as follows:–

Diag: XLVII

Section at the 65th mile



B 30

Spare earth being thrown in rear of the Embankments on the plan which has been usually adopted.–

The average depth of Excavation is as follows:–

From the 35th to 40th Mile 6·75 feet
40th to 50th do 9·80 "
50th to 60th do 7·25 "
60th to 65th do 7·94 "

The Soil is good partially accompanied by the Alkali + before alluded to, and occasionally mixed with Kunkur;– it appears to have all the non absorbent or retentive qualities to which I have referred as characterizing the excavated Channel in the Mynpooree and neighbouring Districts

The depth of Wells measuring from the Surface of the Earth to the Surface of water, is

On the Left of the Canal Line		on the Right of the Canal	
Maximum	31 Feet	Maximum	105 Feet
Minimum	21 "	Minimum	21 "

to that of the water

Continuing from the Bridge at Soonair, the following works have been executed.—

1st Bridge at Soorson. 3 Arches of 26 feet each. 18 feet roadway with Ghats, Rajbuha and Inlet heads, and a 1st Class Chokie attached.—

2nd Bridge at Kuttana. 3 arches of 26 feet each. 18 feet roadway, with Ghats, Rajbuha and Inlet heads attached also a 2nd Class Chokie

3rd Seyra Bridge at. 3 Arches of 26 feet each. 18 feet roadway with Ghats Rajbuha and Inlet heads, and a 2nd Class Chokie attached

4th Bridge at Peydhut 3 Arches of 26 feet each. 18 feet roadway, with Ghats, Rajbuha and Inlet heads, and a 2nd Class Chokie attached

5th Bridge at Kana Kowa 3 Arches of 26 feet each. 18 feet Roadway with Rajbuha and Inlet Heads. Ghats and a 2nd Class Chokie attached

6th Bridge at Puteekna 3 Arches of 26 feet each. 18 feet Roadway, with Ghats, Rajbuha and Inlet heads and a 1st Class Chokie attached

7th Bridge at Burragaon 3 Arches of 26 feet each. 18 feet Roadway, with Ghats Rajbuha and Inlet heads and a 2nd Class Chokie attached

8th Bridge at Koosyari — 3 Arches of 26 feet each. 18 feet Roadway, with Ghats, Rajbuha and

and Inlet heads and a 2nd Class Choki attached.

9th Bridge at Futti Khan Via Nuggla. 3 Arches of 20 feet each - 18 feet Roadway with Ghats Rajbuha and Inlet Heads and a 2nd Class Choki attached.

10th Bridge at Gihror - 2 Arches of 33 feet each - 25 feet Roadway - with Ghats, Rajbuha and Inlet Heads and a 1st Class Choki attached - and connected with an Escape head of 30 feet waterway.

11 th Bridge at Dhrani. 2 Arches of 33 feet each. 18 feet Roadway - with Ghats, Rajbuha and Inlet heads, and a 2nd Class Choki attached.

12. Bridge at Dowapoor 2 Arches of 33 feet each - 18 feet Roadway - with Ghats, Rajbuha and Inlet heads, and a 2nd Class Choki attached.

In advance of the 65th mile and continuing our progress to the 120th Mile of the Course of the Etawah Branch, we by making a turn round the village of Ganosi, escape the heads of the Phoora and the Khneea Rivers, tributaries of the Rinde which in one collected stream enter ~~the Rinde~~ the Sankeneptaind River near the village of Chimwanmow ~~At the 65th Mile~~ The Rinde and the Seringoor, which up to ~~the 65th mile~~ have been running in a direction nearly parallel, approach

65th to 120th Mile

approach each other at that point within a distance of 5½ miles and afterwards gradually separate, the former taking a ~~course~~ ~~ending to the North~~ Northerly, and the latter ~~inclining to~~ a Southerly direction; their bearings are on a sweep which on a cross section at the Town of Ayawa, places the two Rivers at a distance of 23 miles from each other, an extreme distance which in the neighbourhood of the 120th Mile and between the two Towns of Puhpoond and Mungulpoor, is reduced to 12½.

The Northerly direction taken up by the Rinde, and the sweep that at this point of its course it takes to the left, touching near upon Sukrava, a town ~~which~~ is in close connection with the Cawnpoor Terminal line, lead, to a desertion of ~~the~~ its watershed, the Capel ~~which~~ proceeding ~~continues~~, parallel to the Seyngoor River and on the right of the Ahmeea, a tributary of the Rinde. The Ahmeea, in fact, from the neighborhood of the 65th Mile, and between the villages of Katum and Gangsi near which it rises takes up the parallel course upon which the parent River had up to this point been running; and in this respect bears some resemblance to the Pandoo and Esun as described in a former part of this Chapter.

The position of the drainage in this neighborhood will be best shewn by a

Diagram

Diagram

Diag: XLVIII. B31.

The length of the Annecca from its heads to its junction with the Runde is fifty Miles, that of the Phoora thirty five; the former rises in a very extensively ramified series of hollows, of which that near the Village of Kakun appears to be the most remarkable, and the latter rises in the vicinity of Soj. The superficial area of land included between the Annecca and the Runde may be estimated at 450 Square Miles, Soj, Kishnee, and Ayrwa being the principal Towns, each of which give their names to Pergunnas. The Sections or Spits of land formed by these Rivers will receive their Irrigation from the Rajbuha Heads A and on the upstream Canal side of the Gangsi bridge; the course of the Rajbuhas for this purpose being shewn in the Diagram by dotted lines. The tails of these Rajbuhas are in the above Sketch

Sketch represented as falling into the Canal again after crossing the Ahneea by aqueducts, ~~and I am inclined to think that the~~ a design that might be carried out with great advantage, as it would admit of a continued supply being allowed to pass off from the Canal above Gangse, whilst at the same time a perfect command would be held over that supply, with the full power of cutting it off in cases of necessity.

I may remark here that the Sirsa River which, in fact, is a branch of the Seyngoor, (which separates itself on the right from the main line south of Tulcysun and near the Town of Oomrungah in the Muttra District) rejoins ~~the Seyngoor~~ that river at a point on its course lying between Kishnee and Etawah. The Sirsa passes on its left the Towns of Shekoubad, Sirsa Ginj, and Sustwuntnuggur; it can hardly be considered as having any influence on the works of the Canal, excepting as far as relates to the course and direction of Rajbuhas, but it so repeatedly crosses the line of Mr Dodsworth's cross sections, and consequently takes so prominent a place in the Tables; that its existence ought not to be passed over.

4 Feb 1840

With this preliminary Sketch of the country between the 65th and 120th Mile, I shall proceed

proceed with the detail of the country over which the line of works has been carried.—

The course of the Canal which at the 65th mile, is on a curve ~~of~~ having a radius equal to 20,000 feet, continues this course passing the village of Gangsi until it reaches the 68th Mile; Immediately in the neighborhood, and on the approach of the line to the village of Gangsi, a shallow tract of ground, connected with the hol-=lows at Taj and Oodumna is passed; it appears to offer no difficulty, and to ~~place~~ cause no im-=pediment to the drainage, which however, can if necessary be carried into the Rinde which by a sudden twist lies within a Mile of the low ground in question. In advance of the 68th ~~Mile~~, the line passes over a high country as far as the 80th Mile, coming in contact with a ~~Dee~~ shallow ~~only~~ of no importance, which occurs at the 73rd mile, ~~and this is of no importance~~; it is one of the extreme heads of an extensive line of drainage that joins the Seyngoor under the village of Oojyani

At the 80th and 81st miles intersections of the drainage lying between the Ahneea and the Seyngoor Rivers take place, under somewhat peculiar cir-=cumstances; as a line of un-=interrupted hollows connects the two Rivers, although at both points the natural slope most unmis-=takeably lies across the line upon which

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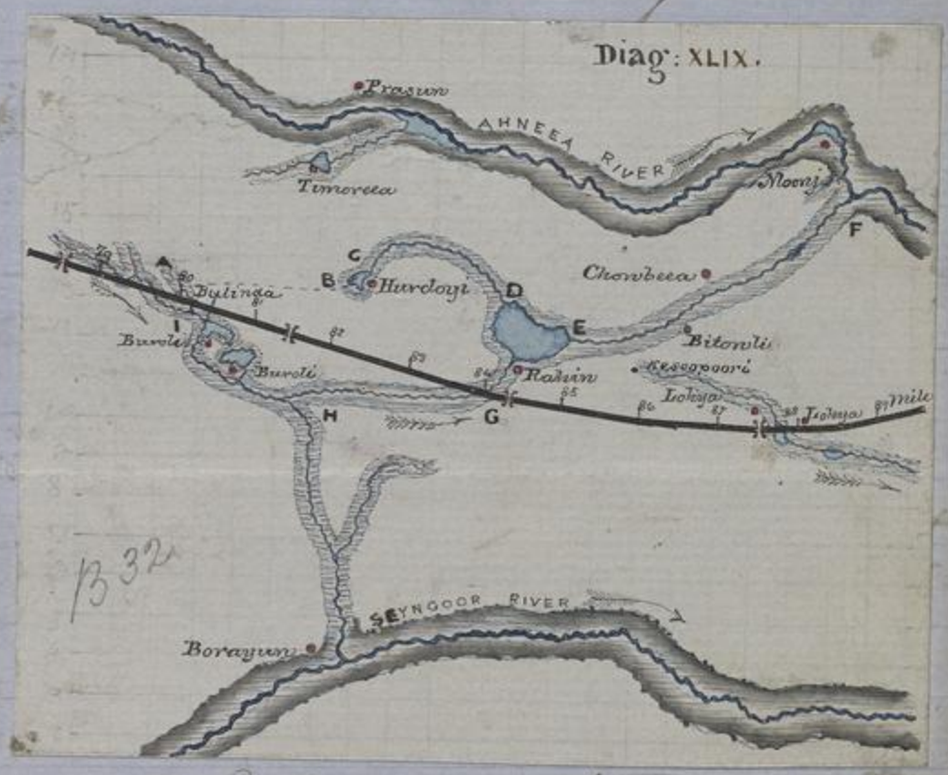
which the Canal crosses; The nature of the drainage will be best shewn in a diagram.-



The head of this drainage reaches the line at the point of intersection with the 80th Mile, after having passed over about 2 Miles of country running parallel to the Canal; at this point therefore the Canal Embankments cut off at least 2 Square miles of the Catchment basin which naturally belong to the Burolí Sheels; at the 81st Mile again the water which during the high floods passed off from the Burolí Sheels towards the great Lake at Radin is intercepted by the Canal Embankments from its natural line of Escape. It is perfectly obvious that any interference caused by the Canal works at the 81st Mile can be easily remedied by deepening the line of hollows which communicate with the Seyngoor; the natural profile of the Country points out this as the remedy; the fall from the 81st Mile to the bed of the Seyngoor under the Village of Borayuw being (81 30·6 - 44 6·5) 15·9

15 9 feet, on a length including
all the tortuosities of the course
of less than 6 miles - At the 80th
Mile however, the remedy is not
so simple, the slopes of the country
are by no means favorable, and
it will be necessary to relieve
the intercepted drainage by an
artificial cut, 2 miles in length
extending from the low ground
A to the Bundoyi Wheel at B, and
to clear out the low line of hollow
connecting that Wheel with the
Rubin Lake - A portion of the
rain water collected on the left
of the Canal in the neighborhood
of the Village of Bulinda, will
undoubtedly escape into the
Inlets of the Bridges and obtain relief to the
extent of their capacity, ~~obtain a certain relief~~; the line of Raj-
-buha, moreover, which will
necessarily pass across the country
in the neighborhood, will not
only receive a great deal of the
flood drainage, but ~~it~~ will
modify the natural watershed to such
an extent, as to extinguish its
existing ~~natural~~ boundaries -
I have no doubt, however, that
~~it will be very desirable, that~~
an efficient and well cleared out
Channel not less than 15 feet in
width, should be maintained
on the line extending from the
80th Mile by the Bundoyi and
Rubin Wheels to the Ahnsea
River, on the line marked in
the above Diagram A B. C D. E F and
that Channels of similar dimensions
should be excavated on the Right

Side

side of the ~~Channel~~ Canal from the 80th and 81st Mile, or from the points marked I and G to the junction of the natural hollows at the point H. from whence the nulla leading to the Seyngoor, ought to be kept well open so as to admit of a free passage for the drainage water.—

With the works above specified, and with an annual inspection to secure their efficient clearance from either natural deposits, or from artificial bunds placed over them for the purposes of irrigation by the Zumeendars I see no reason why the difficulties of this part of the line should not cease altogether, the works in fact for ~~obviating~~ obviating ~~of~~ these difficulties will add greatly to the relief of the neighboring country in the rapid removal of flood water towards the Ahneea on one side, and towards the Seyngoor on the other

In advance of the 81st Mile at Rahin the Canal runs on a course almost due South East until it reaches the 82nd Mile, whence from the village of Lohya it bears more to the East, its course being influenced by the direction ~~taken by~~ of the Ahneea River.—

At the village of Lohya the Canal intercepts a line of drainage running towards the Seyngoor, and at the point of

of intersection passes through a hollow which may be called the Lohrya Sheel: the line of drainage alluded to, rises at the village of Kesoopoora between which and the point where it comes in contact with the Canal, the distance is 2 miles; I dont anticipate any inconvenience from the interruption to the drainage at this point, a portion of the rain water will escape into the Canal through the Inlet at the Lohrya Bridge, the Rajbuha attached to which will in all probability carry off the remainder.

From the 88th to the 115th Mile, the direction of the Canal continues on a bearing tending Easterly, over a high and well cultivated country, keeping with the following exception entirely clear of drainage: at the 97th Mile, not far from the village of Oominseyra, it cuts off a portion of hollow connected with the low lands lying in the neighborhood of Rowayn, a Town on the right at a distance of a Mile from the Canal embankments: these low lands are drained by the Rowayn Nulla, a tributary of the Seyngoor which enters that River near the village of Chouri. The portion of this drainage which is intercepted by the Canal extends about half a Mile, and has its origin in a Sheel lying

under

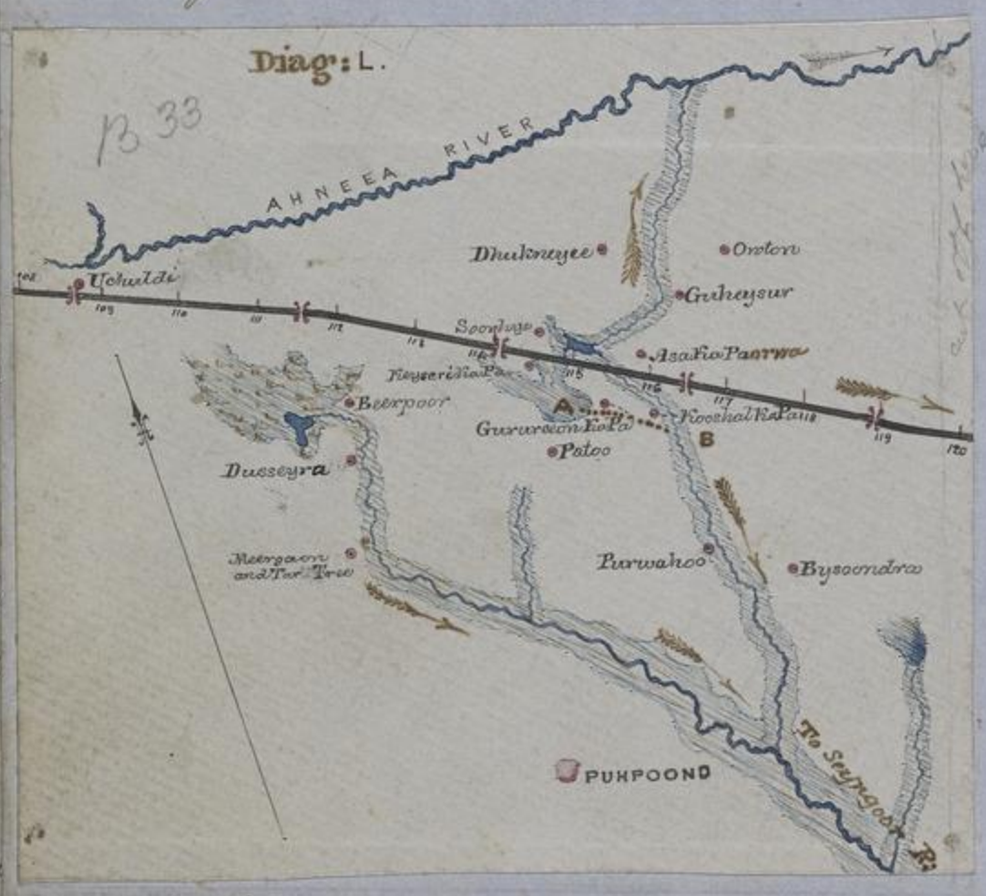
under the village of Chundelon
ka Nugla; no works have been
designed for the relief of this
hollow, nor is any necessity
for ~~them~~ them ~~works~~ anticipated

At the village of Munohunpoor
and at the 106th mile, the line of
canal which passes between that
village and Gopalpoor skirts
the edge of a large hollow sur=
=rounded by villages which
lie on its left; this hollow passes
its flood water off to the Ahnee
River, ~~by~~ by a line of nulla paral=
=lel to which the Canal takes
its course, as far as the village
of Uchuldi. Under this village
the Munohunpoor drainage
forms a junction with the
Ahnee ~~River~~, in a sweep in=
=clining to the right, over high
land until it reaches the 115th
Mile. The Canal in passing
the village of Uchuldi and
on its approach from the 109th
Mile, leaves on its right a very
extensive hollow which as lying
near the village of Beerpoor,
I shall call the Beerpoor Theel;
this Theel is the head of a Nulla
which runs by the villages of
Dusseyra and Meergaon (the
latter marked by a remarka=
=ble Tar tree) and leaving
Puhpoond about 1½ Mile to
its right, joins the Seyngoor
not far from the Town of
Oonja.

and the Canal which at this point runs within a quarter of a mile of that river passes onwards

At the 115th Mile the line
~~proceeds~~ crosses on the watershed as
closely as a straight line could
~~pass~~

do so on ~~pass upon~~ a crooked one, it appears nevertheless to intercept the drainage of a rather extensive hollow near the village of Keyseri ka Poorwa, the position of which will be best understood from a diagram



The low land at A by the intersection of the line of Canal is isolated, and will in all probability require a Cut from A to B for its relief: the above shews a very fair Specimen of the intricacy of drainage and slope with which the Canal ~~is~~ has to contend at parts of its course ~~connected~~.

From the 115th to the 120th Mile the Canal passes on high and cultivated ground to the village of Devipoora, the South and East Trigonometrical Station of Seyhud khas lying about 2 miles on its right.

At the village of Mulhosi which is situated at the 103rd Mile of the Course of the Canal,

an

an outlet with a waterway of 30 feet in five Openings of 6 feet each is designed for the pur=poses of Escape into the Seyn=goor River. The Cut from the Outlet will be directly at right angles to the course of the Canal and ~~mail~~ may either be carried into the bed of the Seyngoor, or as the fall appears to be sufficient, it ~~will~~ may terminate at the Raj=poora Nulla, a line that runs nearly parallel and north of the Rowayn Nulla, a tribu=tary which has been before described as entering the Seyngoor under the Village of Chowri. A cross section taken from the surface of the country over which the Canal passes, in a direct line, and on the course of the Escape Channel to the Seyngoor, shews that the bed of the latter is depressed to an extent of 34·05 feet, and that the beds of the two inter=mediate Nullas which would be intersected by a straight line of Cut, are as follows. —

	Below Surface of Country at the Canal	Distance from the Canal
	Ft.	Ft.
Rajpoora Nulla	14·1	8000 feet
Rowayn do	14·81	17000.
Seyngoor do	34·05	20000.

For further remarks on this line see Part 3. Chap 2. Sec III under the head of Levels

The Slope of the Surface of the Country from the 65th to the 120th Mile is equal to 57·938 or on an average of 0·998 feet per Mile

Mile. At the 72½ Mile a gene=
=ral depression of 2 feet in the
surface of the Country takes
place similar to that which
I have described as occurring
elsewhere, especially at the
57½ Mile of the Course of the
Line; — This sudden change
of levels at the 72½ Mile, how=
=ever, affects in no way the
Slopes of the Canal bed, which
are continued uninterruptedly
at 12 Inches pr Mile, although
it acts so far beneficially as to
reduce the depth of digging,
which up to this point had
been somewhat in excess to
that required for the height
of the Towing Path. —

The relative position of the
beds of the Rivers as deduced
from Mr Dodsworth's cross
sections will be shewn by the
following table; the Plus or
Minus quantity in the Table
denoting the depths above or
below that of the Rinde. —

(p. [illegible]),

tandem Lpr

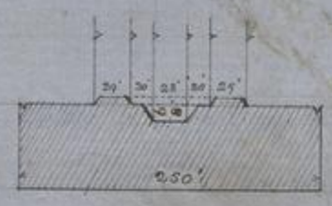
Distance in miles from Nanoor on the Rinde	Phoria River	Siron of Soj	Ahneea River	Ravine of Comunsepa	Ravine of Pulspronna	Seppapan River	Sirja River	Ravine of Ajeelmull	Town of Sukhnao	Town of Elawah	Ravine Nullah near the Jumna River	Wells Left of the Canal Max:	Wells Left of the Canal Min:	Wells Right of the Canal Max	Wells Right of the Canal Min
	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.	F.
70	–	–	–	–	–	-14·70	-0·30	–	–	–	+14·74	38	23	90	23
75	–	–	–	–	–	10·45	1·50	–	–	–	8·56	38	25	90	25
On Soj 80	–	+12·24	–	–	–	9·68	3·00	–	–	–	9·82	33	18	90	31
85	–	–	+10·68	–	–	7·47	1·06	–	–	–	10·94	35	24	90	30
On Elawah 90	–	–	10·23	–	–	9·72	–	–	–	+22·70	22·27	40	29	90	35
On Comunsepa 95	+12·11	–	14·83	+19·84	–	9·99	–	–	–	–	14·15	40	28	90	33
100	8·63	–	16·64	–	–	9·71	–	–	+26·35	–	16·93	40	28	90	30
105	6·33	–	13·41	–	–	8·99	–	–	–	–	21·25	32	24	105	30
On Ajeelmull 110	–	–	12·45	–	–	4·70	–	+27·26	–	–	27·20	27·5	22	77	26
On Pulspronna 115	–	–	–	–	+15·38	5·09	–	–	–	–	29·30	32	20	72	25
120	–	–	–	–	–	13·73	–	–	–	–	26·24	37	37·5	80	37

The Section of the Canal
Channel

Channel at the 120th mile is ~~as~~ specified in the following Diagram:—

Drag: LI.

Section at the 120th mile



1330

the distribution of spare earth being arranged for as in former cases.—

The average depth of Excavation is ~~as follows~~:—

at the 70th mile		6·95	
75th	"	4·90	6·30 (mean of 5 miles)
80th	"	5·36	6·44 Do. "
85th	"	7·56	5·83 Do. "
90th	"	4·59	5·23 Do.
95th	"	6·40	5·38 Do.
100th	"	7·38	5·92 Do.
105th	"	9·41	5·78 Do.
110th	"	7·58	6·88 Do.
115th	"	4·71	5·22 Do.
120th	"	8·93	6·58 Do.

The soil is very good, occasionally mixed with kunkur, which is generally sprinkling met with in small pieces, gravel like seldom in masses; but all available for lime burning for mixing with Cement, or for metalling Roads.— The soil appears to be of the same retentive quality as that before described; and as such is especially favorable for the purposes of economizing the supply of Canal water.— Oosun soil, or that with which the Alkali is ~~in Conjunction~~ mixed is met with here and there over the whole of the Country through which the Canal passes in its progress from the

A A, 553; v.i.

the 65th to the 120th Mile

The maximum depth of locks is 105 feet and the minimum depth is 18 feet, measuring from the surface of the Curb to the surface of the water.

Continuing from the Bridge at Sowapoor, the following works are designed for this portion of the Canal

1st Bridge at Gangsi - 2 Arches of 33 feet each - 18 feet Roadway - with Ghats, Rajbuhs and Inlet heads, and a 2nd Class Choki attached.

2nd Bridge at Nutaoli - 2 Arches of 33 feet each - 18 feet roadway, with Ghats, Rajbuhs and Inlet heads, and a 2nd Class Choki attached

3rd Bridge at Boojea - 2 Arches of 33 feet each - 25 feet roadway, with Ghats, Rajbuhs and Inlet heads, and a 1st Class Choki attached

4th Bridge at Bussoo ka Nugla 2 Arches of 33 feet each - 18 feet roadway - with Ghats, Rajbuhs and Inlet heads, and a 2nd Class Choki attached.

5th Bridge at Tukrao - 2 Arches of 33 feet each - 18 feet roadway with Ghats, Rajbuhs and Inlet heads, and a 2nd Class Choki attached

6th Bridge at Bulinda 2 Arches of 33 feet each, 18 feet roadway - with Ghats, Rajbuhs and Inlet heads, and a 2nd Class Choki attached.

7th

7th Bridge at Burroola
2 Arches of 30 feet each. 18 ft
Roadway with Ghats, Rajbaha
and Inlet heads, and a 2nd Class
Choki attached

8th Bridge at Rahin. 2
Arches of 30 feet each. 18 feet
Roadway - with Ghats, Rajbaha
and Inlet heads and a 1st
Class Choki attached.

9th Bridge at Dhrya
2 Arches of 30 feet each. 20 feet
roadway - with Ghats, Rajbaha
and Inlet heads, and a 2nd Class
Choki attached

10th Bridge at Budumyee
2 Arches of 30 feet each. 18 feet
Roadway - with Ghats, Rajbaha
and Inlet heads, and a 2nd Class
Choki attached.

11th Bridge at Doreyea
2 Arches of 30 feet each. 18 feet
Roadway - with Ghats, Rajbaha
and Inlet heads, and a 2nd Class
Choki attached

12th Bridge at Oomurseyra
2 Arches of feet (20) each. 18
feet Roadway. Ghats, Rajbaha
and Inletheads, and a 1st Class
Choki attached

* Bridge at Bahirpoora
2 Arches of 26 each. 18 feet
Roadway with Ghats, Rajbaha
and Inlet heads and a 2nd Class
Choki attached

T. Slater

12th Bridge at mulhosi
2 Arches of 26 feet each. 18
feet Roadway - with Ghats
Rajbaha and Inletheads and
connected with which is an
Escape of 30 feet waterway,
a 2d Class Choki is attached
to these works -

15th Bridge at Munohurpoor
2 Arches of 26 feet each, 18 feet
Roadway

Roadway with Ghats, Rajbuha and Inlet heads and a 2nd class Choki attached

16th Bridge at Uchuldi 2 Arches of 25 feet each. 18 feet roadway. Ghats, Rajbuha and Inletheads attached. as also a 1st class Choki.

17th Bridge at Koomhara 2 Arches of 25 feet each. 18 feet roadway. with Ghats, Rajbuha and Inlet heads, and a 2nd Class Choki attached.

18 Bridge at Kundhown 2 Arches of 25 feet each. 18 feet roadway. with Ghats, Rajbuha and Inletheads and a 2nd Class Choki attached

19th Bridge at Devipoora 2 Arches of 25 feet each. 18 feet Roadway. with Ghats, Rajbuha and Inletheads. and a 1st Class Choki attached.

20th Bridge at Bijhye. 2 Arches of 25 feet each. 18 feet Roadway, with Ghats, Rajbuha and Inletheads, and a 2nd Class Choki attached.

The last section ~~left us~~ terminates at the 120th mile, at a point of the Canal situated about 5 miles North of the Town of Pulpoond in the Etawah District. From this point, the direction of the alignement is in a general way in prolongation of that on which it reached the 120th mile viz: about East South East, or a few degrees nearer East; on this bearing it continues as far as the 1st 2nd mile

or

or to the heads of the Noon River; succession of
from thence to the 114 5th Mile, a
Curves on a constant Radius of 2000 feet, de-
-livers the line on an entirely new
bearing, deserting the course of
the Rinde (which proceeds on-
-wards to the Town of Kora Ja-
-hanabad) and taking for its
left boundary the drainage of
the Noon River. This new bearing
which is to the South East con-
-tinues to the 163rd mile and to
the neighborhood of the Town of
Rawun; from this point and the
Curve on a radius of 2000 feet fixes
a starting point (at the 165th mile)
for an alignement which run-
-ning due South delivers the
Canal water into the Jumna.

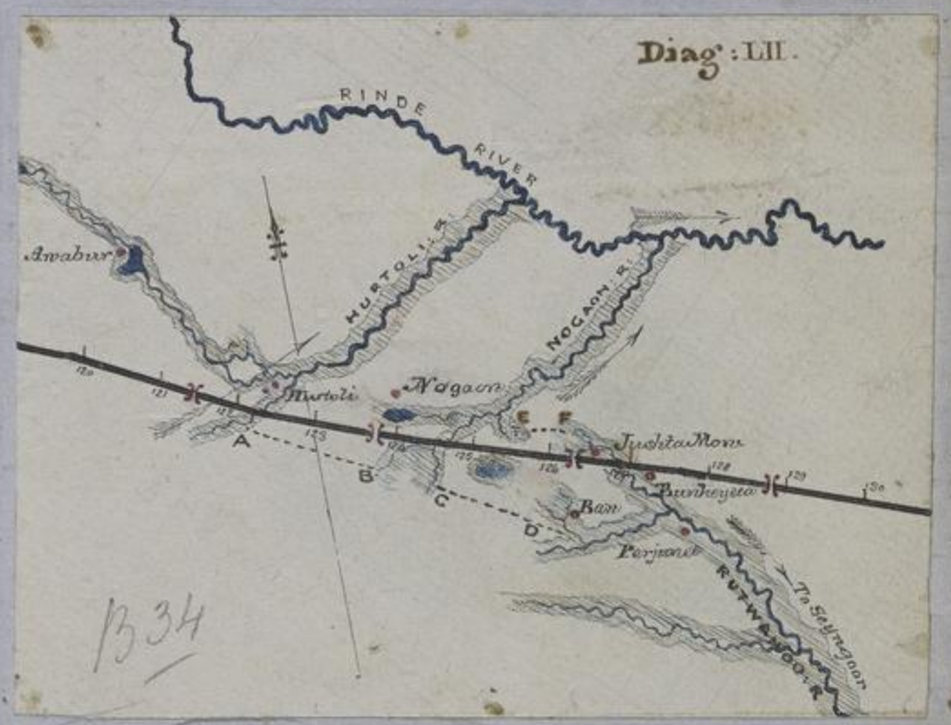
It will be understood, there-
-fore, that the direction of the
Canal on that part of it which
is above described, after running
parallel to and between the
Rinde and Seyngoor, as it has
done from its head downwards,
takes at the 114 5th mile a curve
-abouts a sweep to the South
passing round the Towns of
Ukhunpoor and Rawun leaving
the Rinde River altogether, and
entering the Jumna, bounded
on its left by the Noon, and on
its right by the Seyngoor. ~~to~~
~~which throughout its whole~~
~~course it has maintained a~~
~~parallelism~~.

The strip of country
through which the Canal runs
between the Rinde and Seyngoor
is at the 115th mile or on a Section
taken

taken at Pulchpoond equal to
1/4 Miles in width; at the 1/4 15th
Mile, or at a point between the
Villages of Roora and Tugaeen
where the change of direction
takes place, this width is de-
-creased to 11 Miles; the line of
the Canal maintaining its
position as closely to the water
shed as possible, and running
within 4 Miles from the course
of the Rinde - In its passage
onwards and in its course
Southward towards the Iumna
the line of Canal takes up a
more centrical position between
~~equal to~~ the Joon and the
Seyngoor (which are separated
by a distance of about 11 Miles)
a circumstance entirely influenced
by the water shed, and by the
extensive and scattered drain-
-age connected with the former
River, not only at its immediate
heads, but on its whole course,
to which reference will be made
in greater detail presently, when
bringing under review the
alignements as connected with
the detail of cross drainage. -
To this review therefore we will
proceed, the drainage connected
with the hollows near Keyseri Ka Poorwa
and Gurreeon Ka Nuggla having
been before described. -

Leaving the Villages above
noted the line of Canal reaches
the 1/4 1st Mile, on a fine open
and cultivated country, with
less interference from cross drain
-age than has been usual on
such

such a length of course; on this whole line of 26 miles there are only 3 points, viz: at the 122nd, 124th, and 127th Miles where drainage is intersected at all, and the hollows cut off by this intersection lie so conveniently with regard to the Rutwahoo River, that any annoyance ~~that~~ which may arise ~~to the Country~~ can be very easily remedied. A Diagram shewing an outline of the Country will be the most satisfactory method of conveying information on the detail of the intersections above alluded to



It will be observed that the hollows which are cut off by the Canal at the 122nd and 124th Miles are portions of drainage connected with two distinct tributaries of the Rinde; to these I have, to facilitate reference, given names derived from villages lying at their heads. Both those portions of the Hurtoli and Nogaon tributaries which have been separated from their parent drainage can be con-

nected

each other and with
=nected with the Rutuahoo,
by cuts as above marked at
A B and C D: the lengths from
A to B is not more than 2 miles,
and that from C to D does not
exceed 1¼, ~~the cost of~~ a ditch,
~~therefore~~, that need not exceed
10 feet in width, would ~~be no~~
~~impediment~~ lead to the complete
drainage of the hollows. I
may remark, however, ~~as I~~
~~have done before~~, that these
lines of drainage look more
formidable in a map than
they ~~are in nature~~ are in reality, it is ne=
=cessary to exaggerate in shade
the lines of drainage when shewn
in a map although such lines
may be depressed only a few
inches below the level of the
surrounding country; our
maps too represent the hollows
as filled with water; a circum=
=stance that naturally ~~only~~
occurs only during heavy rains;
many of the hollows, therefore
and the above amongst the
number, which are described
as being thus cut off and
isolated, are depressions of such
an inconsiderable amount
that in all probability no
remedies will be required at all.

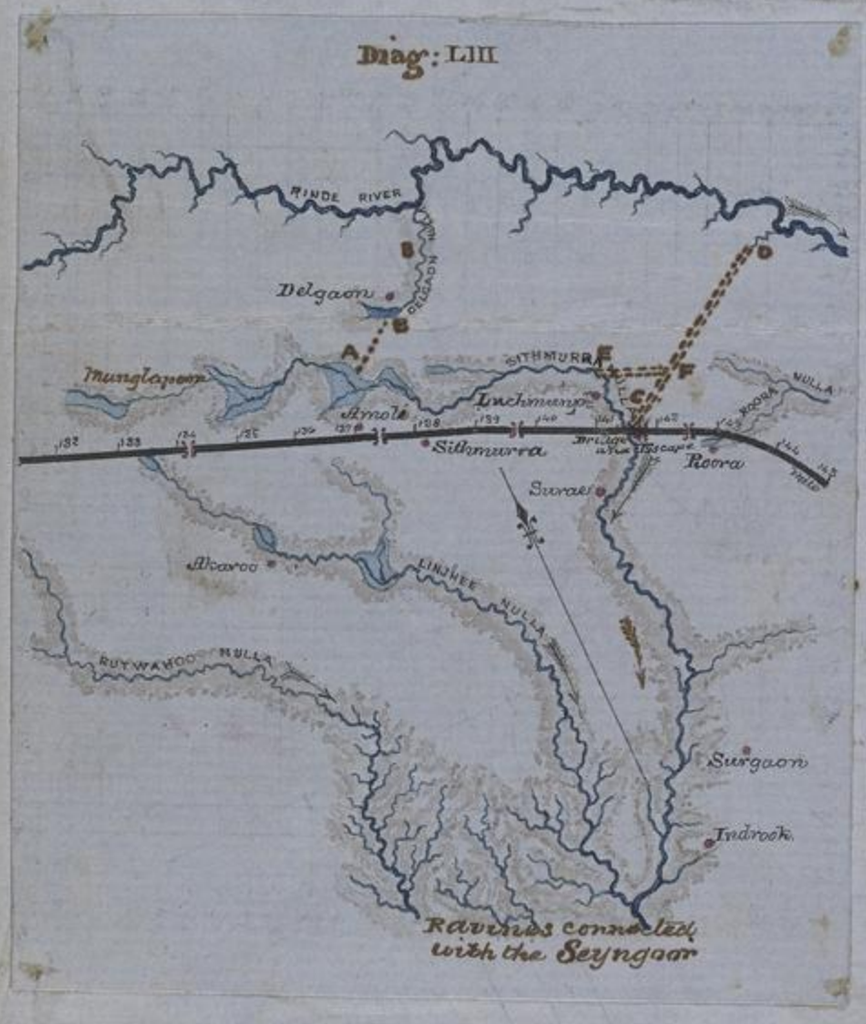
At the 12¾ Mile, a portion
of one of the heads of the
Rutuahoo lying in the neigh=
=borhood of the Village of
Pushtamoo is cut off, and
thrown on the left of the Canal:
the remedy for this, is to con=
=nect it with the drainage
of

of the Ridge, by making the Cut EF into the Nogaon Nulla; a cut the length of which will be considerably under a Mile, will ~~be no impediment here~~ here also lead to a rectification of evil; the fact is that the remedy in all these cases is exactly the same, although in one case it may be more expensive than it is in another; the direct and even line upon which the Canal takes its course necessitates intersection with the heads of drainage which ~~it~~ are scattered about the surface without the least regularity; as this direct line of Canal however passes over the summit level of the Country and intermediately between Rivers, the beds of which are considerably depressed, it is evident that a portion of the water cut off from one slope may be turned into the drainage passing off on the other, and that there ought to be no inconvenience to the drainage of the Country from the introduction of a Canal, or road, which has been conducted on the principles above mentioned.—

At the 1st ~~Mile~~, or another at a point between the 1st and 2nd Miles, the line of Canal after running for 15 miles parallel ~~on a distance of 10 miles~~ comes then in contact with the course of a tributary of the Seyngoor which I call the Sithmuna Nulla; this is the first serious impediment

impediment that the Etawah terminal line has met with, and it is in fact connected with a series of impediments which in describing the heads of the Noon River, I shall enter upon very fully. At the point of intersection the bed of the Sithmurra Nulla is 8 feet below the surface of the neighbouring country, its section is of considerable size, and its bed is three feet lower than that of the Canal. The following diagram will render the description more distinct

Diag: LIII



The Sithmurra Nulla after leaving the point where the Canal intersects it, passes off in a direction almost due South and at a distance of 7 Miles near the villages of Surgaon and Indrook, plunges into a Maze of Ravines which are connected with the Seyngoor. At a point opposite the village of Amoli, at

4PD

at which the Sithmuna drainage has passed through 5 Miles of its course, a cut marked in the above diagram A B B will be made connecting it with the heads of the Delgaon Nulla, which flows into the Rinde River; the difference of level between the two Heels of Amoli and Delgaon which will be thus joined together ~~will be~~ is exceedingly small, the Heels may be considered in fact as on one level; it will be necessary, therefore in making the Cut A B to commence digging from the lowest point in the Heel A and if necessary to extend the Channel as far down as the junction of the Nulla with the Rinde. I would make this Cut 15 feet in width, and on as rapid a slope as the relative levels will admit of, by which means, the whole of the drainage from the head of the Sithmuna River as far down its course as the village of Amoli will be disposed of.—

Garnett

At the point where the Sithmuna River crosses the Canal, it is proposed to establish a bridge, attached to which is an outlet of 18 feet water way divided into three sluices of six feet each; from this outlet a cut or Escape Channel will be directed towards the Rinde on the line marked C D in the Diagram. this cut will be made 30 feet in width, and will have

have a slope of bed equal to
½ feet per mile: The Rinde at
the point where the Cut to
will join it, has become a deep
and wide Channel, with a de-
=pression below that of the
Sithonnia Nulla at C of at
least 25 feet; and as the distance
between C and D is 4 1/2 Miles, the
slope will be most amply suf-
=ficient for the purposes of
Escape. By this artificial
Channel the Sithonnia Nulla
or that portion of it which re-
=mains after it has been de
=prived of its upper drainage,
will pass off towards the Rinde
and that this may be more
satisfactorily secured a Second
Cut EF continued in prolonga-
=tion of the line of River will
still further ease off the Current
during floods, and at any rate
will prevent the water from
collecting near the Canal
Embankments at C, and in
a great degree remedy the
awkward and abrupt turn
that the Sithonnia drainage
would otherwise have in
passing off down the Escape
Nulla. (For further remarks on this line see Part 3. Chap. 2. Sect III and in the head of Sect III, ii, 3,

The plan upon which
I have disposed of this drain
-age is similar in principle
to that which has been before
described on the Campoor
Terminal line at the village of
Ginowli, at which point
the heads of the Rinde are

turned

turned off to the East Kalli Nuddi by a Channel connected with an escape, much in the same way, as the Sithmina drainage has been turned off at this point towards the Rinde.

From the 11th 1½ Mile the Canal curves round to the south passing close to the villages of Roora and Tugalen which lie on its right, from thence it proceeds straight to the village of Nurhea Situated at the 11th 9th Mile, and lying between two Extensive hollows both of which are crossed by the line of canal, and both of which are connected with the Noon River of which they are the ostensible heads.

Both at the 11th 3rd mile at the village of Roora, and at the 11th 5½ Mile at the village of Tugalen, the Canal comes in contact with the heads of Nullas to each of which I have given the names of the villages near which they take their origin. in neither case, is the portion cut off of sufficient consequence to demand works for ~~the~~ its especial drainage; should such, however, be found necessary, the slope of the country towards the ~~Villages~~ Lines of Kingaon and Indrook which lie to the South West and towards the Ravines on the Seyn-goor River, is sufficient to admit of the most efficient relief, at the smallest possible

outlay

outlay –

We now reach the heads of the Noon river, and to these and to the River itself, I am desirous of devoting as much space, as their importance on the Terminal works of the Etawah line calls for. –

The following Sketch will exhibit at a glance the main Topographical features of the Country in which the Canal at this Point of its course comes in connexion with the Rinde, the Noon, and the Seyngoor Rivers

The great object to be accomplished was to carry the line of Canal to the East of the Town of Ghatumpoor, so as to reach the high land in the vicinity of that as well as of the neighboring Town of Kora Juhanabad. I have before when discussing the capabilities of the land lying

on

on the right and left of the Rinde River, described the advantages that the former would derive from Irrigation, as well as the superior claims that it possessed over that lying on the left of the River, which was highly cultivated, and flourishing under the effects of Irrigation from wells, the average depth of which did not exceed 30 feet:- whereas the land lying in the neighborhood of Kora Rahamabad, Ghatumpoor, Gujnare and Rawun ~~were~~ was comparatively ill cultivated, without Irrigation from wells (the depth of which precluded their being used for that purpose) and consequently without the means of ~~giving fertility to~~ cultivation, soil which is in itself excellent, ~~fertile~~; the pergunna of Ghatumpoor is in fact the least remunerative portion of the Cawnpoor District, and it was naturally the desire of the Revenue authorities, as well as my own, to give them the full benefits of Canal Irrigation -

With regard to Navigation also, it was deemed desirable that the Canal Terminus should be as little removed from the junction of the Rinde with the Jumna as possible. as the best and most efficient part of the Jumna for the purposes of navigation lies below the Towns of Runeerpoor and Kulpi, and below the junction of the Kane and the Rinde Rivers - This although a

a Secondary object was one of the causes that led me to prefer a line that would pass between the Towns of Ghatumpoor and Kora Ruhanabad, and finally terminate in the Jumna close by the junction of the Rinde with that River.—

Plates Nos V & VIII of the Atlas, gives in detail the whole of the intricate and complicated drainage connected with the Rinde, Noon and Seyngoor, at the point where the Noon rises; the general lining out of which will be understood by ~~the above~~ Diagram LIV which is drawn in sufficient detail to shew the cause of my selecting a line which differs very materially from that which I had originally proposed.—

In describing the Choiya Pandoo, and other Rivers, with which during its course the line of Canal has come in contact, I have in fact given an accurate description of the character of the Noon River; the same shallow depressions, scattered over an extensive area, the same labyrinth of entangled Nullas, and a similar irregularity in direction, are characteristics of the Noon, as they were of the before mentioned Rivers.— I shall, however, describe the Noon in the words of the report of Lieut Johnstone, an officer of the Bengal Engineers who

who was deputed to survey the
Country in the vicinity of
Ghatumpoor, and to trace to
their sources the lines of shallow
connected with the River. plate
No VIII is the map of the Atlas, which ac-
-companied Lieut. Johnstone's
report.

"The Noon is a River which
"for the greater part of its course
during six months in the year
is but a small stream, although
it collects nearly the whole drain-
-age of the Country between
the Rivers Rinde and Seyngoor-
-Towards to the Jumna into
which it falls, it increases very
considerably in importance and
runs through a maze of ravines
of a very formidable nature
It rises in a large Theel or series
of Theels to the North of Ukbur
-poor about seven miles above
the point where it is first shewn
in the Plan* - close to its source
the level of the bed is about 40
feet above that of the Rinde
and about five miles distant
from it. The level of the bed
of the Seyngoor is not shewn
but the Country in the imme-
-diate vicinity of its ravines
is about 60 feet below that by
the Rinde and Noon."

"About 5 miles East of
Ukburpoor, near the village of
Tulounchi is another large
Theel from which springs the
Nika

* The direction of these lines of Theels is shewn by the dots which have been entered from Lieutenant Whitings Surveys. —

Kuhar Nuddi, one of the principal feeders of the Noon, at the village of Nonnma it joins the main stream which then proceeds in a more southerly direction and near Ilhalia is at its greatest distance from the Rinde.-

"By reference to the plan it will be seen that about 3 miles above the junction, the Noon approaches very close to the Rinde, while its feeders receive drainage from its vicinity: very shortly below this, the difference of level between their respective beds is reduced to about 20 feet.-

"The double line on the plan shews the direction I should be inclined to recommend for the canal were it decided that it should run between the Noon and the Rinde; though for various reasons, I am led to believe, a preferable line for the main canal both on account of expense and difficulty of construction would be found between the Noon and the Seypgoor; while a branch might be carried along the North side of the Noon for the supply of the Country lying there.-

"In the line marked out, it will be seen that several of the heads of drainage of the Noon are cut off; this I believe would be found unavoidable, but the great depth of the bed of the Rinde would I think render the difficulty of-

of turning the small portion of drainage very inconsiderable. The Rinde during this portion of its course is environed by Ravines extending nearly half a Mile on either side.

"As the line advances it approaches very near to the Rinde at the Village of Burnia and along with the River takes a more Easterly direction from that point. Near the crossing of the Road from Shatumpoor to Canonpoor it again intersects lines of Noon drainage though the River itself is now many miles distant. Here, in a large Oosun plain, is another of the Noon feeders which drains the Country for several Miles. The line from this crossing follows the direction of the levels for some little way, and is in this place and for some distance, on the Ridge between the two lines of drainage. Further down near Passikhera it passes thro a large Theel from which runs a Water course into the Rinde; almost immediately on leaving its source, this Nulla becomes an obstacle of a most serious description, and to cross it at all near the Rinde, would be attended with considerable difficulties.

"The drainage below this becomes rather complicated and the line almost immediately cuts off a portion of another large Theel which however drains into

into the Noon - It then passes
down to Duhanabad and
continues with very little de-
=viation through a portion of
Country which I did not com-
=pletely examine, though from
appearances in its vicinity
and observations taken in crossing
it, I am led to believe that it
is very nearly on the highest
ground; from the vicinity of
Bussea where my levels again
approach it, its course is clearly
marked out and any deviation
right or left would lead into
a mass of Sheels and Ravines
which bound it on either side." -

Lieut. Johnstone continues
"The line marked is the only
one by which the Jumna can
be approached, at this point,
without passing through
difficulties almost if not quite
insurmountable, and even by
this I fear the fall into the River
would be far from satisfactory
For several Miles on either side
of Bara near which the pro-
=posed junction would take
place the Jumna flows al-
=most without a turn, and
with its entire stream on the
further bank, separated from
this stream by tremendous
Ravines and a wide expanse
of Sandy beds. I fear that the
construction of the Canal so
as to admit of its being used
for Navigable purposes would
be found all but impossible.
were this laid aside, the Fall
might

might be thrown into any of the numerous water courses that cut the country in every direction.—

"In concluding my descrip=tion of the line laid down I need only state, that throughout a very great portion of its course, it runs through wide plains of Oosur, with patches of cultivated land near the villages. The wells are in most parts very deep, and the supply of water limited, un=certain and expensive, so that the necessity for some assistance is most apparent. This line has no very great difficulties to contend with, except at its junction with the Gumma, where they are of so serious a nature (if the Navigation is considered) that I should be inclined to recom=mend the Canal being carried if possible in some other direction.

"If the main line were constructed on the South side of the Noon it would be shorter by about 20 miles, and could I believe be carried on quite as high (if not a high=er) a level, and the turning of drainage would be at=tended with fewer difficulties as the bed of the Seyngoor is laid down by Mr Dousworth 30 feet lower than that of the Rinde. The Revenue Survey Maps too shew a salient angle of the Gumma which

would

would appear to offer a most convenient point for the junction"

The consequences of Lieut Johnstones operations were fatal to the project for carrying the Canal on the Ghatumpoor line which was clearly one of great difficulty, as far as Navi=gation, and its junction with the Summa were concerned; where=as this direction pointed out by Lieut Johnstone as lying between the Noon and Seyngoor, was not only with reference to the terminal works, infinitely more convenient; but it possessed all the advantages of high level which for the purposes of Navi=gation gave us a full com=mand over the lands lying to the left of the Noon; there were, moreover, no impediments from drainage, as the low lands crossed near the Town of Akbunpoor were not only in the immediate neighborhood of the deep ravines which bordered the Seyngoor, but they were actually connected with them by a line of hollow=

The line therefore chosen by Lieut Johnstone and which I have adopted, lies between the Noon and the Seyngoor Rivers; it merely touches upon the Ghatumpoor Purgunna on its extreme Western bound=ary, but at the same time it holds a position which will ensure to the whole of the

Purgunna

purpose an ample supply of water for the purposes of Irrigation. The means by which this may be effected are

1st By one main line of Rajbuha occupying the course which Lt Johnstone has laid down for that of the main Canal at the Jugaeen Bridge, and at a point where it would not be interrupted by the Jugaeen Mills. + + + From the main line Branches would be thrown off for the irrigation of the different Spits of land lying between the Tributaries of the Noon –

2nd By the ordinary Rajbuha Heads, which are constructed at each of the Bridges between Sithmuna and Rawun; four of which viz those at Sithmuna, Roora, Ukhunpoor and Nurhea in addition to that at Jugaeen would give an aggregate width of water way equal to 30 feet, and as their levels are favorable, would be ample for any supply that the Country could call for. In this case the Jugaeen Rajbuha would be joined by those from the Sithmuna and Roora Bridges and the collected water would pass on

Lieut

Lieut Johnstone's line, while the others after crossing Irrigating to the country lying between the Canal and the right bank of the Noon, would in either one or two united Streams (whichever might be found most convenient and most economical) be pushed over the Noon by Aqueduct. The Rajbaha heads which are situated below that at the Ukbunpoor Bridge would be specifically devoted to the Irrigation of the tract of Country lying between the Noon and the high bank of the Jumna

The facilities offered by the profile of the Country, for either of these projects is best shewn by a reference to Lieutenants Whitings and Johnstone's levels - The Bridges to which I have referred above are situated at points where the surface level of the Country is as follows.

1.	Sithmana Bridge	487.75	Feet
2	Roora	482.08	"
3	Rugaeen	486.04	"
4	Nurhea	493.31	"
5	Ukbunpoor	493.95	"
6	Korain	503.67	"
7	Jeffinabad	503.46	"
8	Girsee	508.19	"
9	Rhutgoan	509.84	"

The Towns and principal points lying on the land between the Runde and the Noon, which have to be reached from the above points lie on the

Sg 2.B. P.369; 1.1.

the following levels.

Ghatumpoor	518·33
Guynare	510·80
Kora Suhanabad	522·83

The distance from the Sikkimma Road to Kora Suhanabad is, along the line marked by Lieut. Johnstone, about 40 miles. the fall of country in this distance is equal to 36·79 feet or about 0·919 feet per mile –

From Ukbunpoor to Guynare the distance is 9 miles, and the fall of country is equal to 16·85 or 1·87 feet per mile. From Guynare to Ghatumpoor the distance being 11 miles the fall of country is equal to 7·53 or 0·68 feet per mile. the level point at Ghatumpoor however is taken on the North of the Town from whence in the direction of Kora there is a considerable fall. The Town of Ghatumpoor itself lies on a level equal to 508·42 but the Country slopes away on all sides – From the Table above given it will be seen that the points at Grisee & Rhutgaon and ~~Ghatumpoor~~ Guynare are nearly upon one level.

The change in the direction of the Canal therefore which is so manifestly advantageous to the works both in construction and economy of expenditure; has not in any way deprived the Ghatumpoor Pergunna of the benefits of Canal Irigation.

Having

Having thus explained the disposition of the works in regard to the Noon River I shall now proceed with the detail of those on the main line of the Canal which I left at the 149th Mile at the village of Nunhea. The extensive hollows which by the intersection of the Canal both above and below this village, are cut off from the slopes of the Noon, to which they naturally belong, will be drained into the Seyngoor aided by a Cut marked in the Diagram A B, which will connect them with a line of low land ~~which~~ commencing under the Town of Akburpoor, and continuing uninterruptedly to the Ravine heads bordering the Seyngoor River. —

From the 149th Mile the Canal pursues a course to the South East, passing (between the 151st and 152nd mile) the Town of Akburpoor which lies about half a mile on the right: at this point the high road between Etawah and Cawnpoor crosses the Canal. To the 163rd mile the Canal proceeds evenly over a high and well cultivated country passing the village of Girsee which lies close to the right and immediately opposite the 161st Mile; at the 162nd Mile, and about ~~a quarter of a mile~~ 400 yards from the village of Rhutgaon which lies on the left

left, the Canal crosses the head of the line of drainage which as passing under the village I shall designate the Rhutgaon Nulla; this Nulla after running through a course of about 8½ miles joins the Noon near the village of Sinda, and the high road connecting the Towns of Moosannuggur and Ghatrumpoor.

The head of this Nulla lies directly under the village of Girsee from whence to its intersection by the Canal the distance is about a Mile; it is not very clear whether the interruption to this line of drainage will be of material consequence, or whether it will require any remedy for its relief at all: should such however be necessary, a cut must be made from the low land near Girsee to the Seyngoor Ravine heads lying about 3 Miles to the South west under the village of Dursen; a cross section on this line made by Mr Dodsworth is by no means favorable, however the ground in the neighborhood of Dursen being 3 feet higher than that near the village of Rhutgaon. I have no doubt that an examination of the Country lying between the villages of Girsee and the Ravines which are situated near the Seyngoor would lead to the discovery of a line well adapted to the purposes of Escape from

From the 163rd to the 165th
Mile, a curve on a radius of 20000
feet delivers the line upon a
bearing a few degrees to the right
of that on which it had been
previously passing; on this bear-
-ing it proceeds direct to the
Dumna. The Town of Ravun
lies opposite to the 165th mile
at ~~about a quarter of a Mile~~ a short distance
to the left; the Canal passes
Ravun on a moderately cul-
-tivated although a very dry
Country (the depth of wells
being 79 feet) free of all drain-
-age until it reaches the 168th
Mile at the village of Bhambi,
here the extreme southern limit
of a very extensive hollow, upon
which the villages of Mooya
and Sirinuggur are situated,
and which is connected with
the Noon, is touched upon with-
-out any interuption to its
drainage. At the 170th Mile
a hollow of considerable ex-
-tent is crossed at what appears
to be the watershed or summit
level, of 2 lines of drainage
running in opposite directions,
One to the Dumna under &
Moosaninuggur, the other to
the Noon: No impediment
appears to exist at this point
and it will act as the Escape
head for the Locks which lie
below it. Onwards to the
172nd Mile, the line of Canal
proceeds uninterruptedly over an
undulating and barren surface.

at

at this point, however, it reaches the crest of the high land that overlooks the Dumma River; here the lower levels will be gained by a series of locks + which will deliver the Canal into the main River at the 175th Mile.—

The land lying between the Noon and the Deyngoor and through which the Canal passes after it leaves the 145th Mile at Tugalen, may be on an average 10 miles in width, its course (after the passage of the heads of the Noon near Ukbunpoor) being equidistant between the two Rivers.—

The Slope of the surface of the Country from the 120th Mile to the Crest of the high land overlooking the Dumma or to the 172d Mile is equal to 50·68 feet, or on an average of 0·97 feet per mile. From the 172d Mile to the surface of the water in the Dumma River on the 3rd January 1834 the fall is equal to 98·08 feet

The relative position of the beds of the Rivers as de-duced from Mr Dodsworths cross sections are shewn in the following Table; the plus and minus quantities shewing the Elevation or depression in feet from the bed of the Rinda River.—

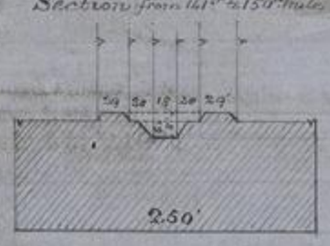
Distance in Miles from Nanoun on the Rinde R:	Seymour River	Town of Oonja	Village of Andarke	Noon River	Town of Ukhunpoor	Village of Silouchi	Town of Moodanagoo	Town of Kusinara	Town of Chatumpoor	Town of Kora Jukamukha	Neighbourhood of the Summa Rivers	Summa River	Wells	
	ft	ft	ft	ft	ft	ft	ft	ft	ft	ft	ft	ft	Maximum ft	Minimum ft
125th	-16·41	+32·28	—	—	—	—	—	—	—	—	+20·68	—	80·41	34·66
130th	-11·52	—	—	—	—	—	—	—	—	—	26·56	—	74·16	44·16
135	-17·77	—	—	—	—	—	—	—	—	—	27·30	—	102·16	45·00
140 Highland	+38·93	—	+38·93	—	—	—	—	—	—	—	35·79	—	92·25	56·75
145 do	+32·69	—	—	+40·27	+45·65	—	—	—	—	—	46·08	—	96·83	46·25
150 do	+31·41	—	—	+22·71	—	+32·20	+35·23	—	—	—	25·23	-67·87	94·46	46·00
155	—	—	—	+19·88	—	—	+31·47	+28·9	—	—	23·9	—	87·00	30·25
160	—	—	—	+23·10	—	—	—	—	—	—	31·95	—	81·33	52·00
165	—	—	—	—	—	—	—	—	+46·56	—	39·40	—	81·08	45·83
170	—	—	—	+11·57	—	—	—	—	—	—	43·21	—	87·41	52·83
175	—	—	—	+21·05	—	—	—	—	—	+30·07	30·61	—	85·91	55·08
180	—	—	—	+23·30	—	—	—	—	—	—	1·08	—	77·58	52·25
185	—	—	—	—	—	—	—	—	—	—	—	-60·10	72·66	58·83

5½ 2 3½ 3½ 3½ 5½ 3½ 1½ 1½ 1½ 1½ 1½ 5½ 3½

The Section of the Canal Channel at the 141st to the 150th Mile, or that portion in which the Ittamma Escape is situated is.

Diag: LV

Section from 141st to 150th Mile



The distribution of Spare earth being arranged in the manner before Specified.—

The average depths of Excavation throughout this line of the Canal is ~~as follows~~:

at the 125th mile		
130th "	}	6 feet
135th "		
140th "		
145th "	}	7½ feet
150th "		
155th "		
160th "	}	9·68
165th "		
170th "		8·25
173rd "		12·00

The

The soil is of a similar quality to that which has been met with throughout the Etawah and Cawnpoor Districts, it appears to be well adapted for a Canal Channel, although in the region of Oosar and Kunkur gravel, the substrata melt away as it were, leaving the sides perpendicular; in other respects the soil is good, and being little absorbent, will be a good medium for economizing the distribution of water.—

The depth of wells is on a maximum 102:16 feet, and on a minimum 30:26 feet, the measurements being taken from the surface of the Earth to that of the water.—

Continuing from the Bridge which is situated between the 118th and 119th Miles near the village of Lukmanpoor, we have the following series of works.—

1st Bridge at Nogaon
52 feet Waterway in 2 Arches;
18 feet Roadway; with Ghats Rajbuhs and Inlet Heads, and a 2nd Class Choki attached

2d Bridge at Bumheya
52 feet Waterway in 2 Arches
18 feet Roadway - with Ghats Rajbuhs and Inlet Heads, and a 2nd Class Choki attached.—

3 Bridge at Shingee
33 feet Waterway in 1 Arch
18 feet Roadway, with Ghats Rajbuhs and Inlet Heads,

and

and a 1st class Choki attached.

4th Bridge at Soreea
33 feet Waterway in 1 arch
18 feet Roadway, with Ghats
Rajbuha and Inletheads, and
a 2nd class Choki attached.

5th Bridge at Sitamurra
33 feet Waterway in 1 arch
18 feet Roadway. with Ghats
Rajbuha and Inletheads, and
a 2nd class Choki attached. Connected with an Escape

6th Bridge at Thundermow
33 feet Waterway in 1 arch
18 feet Roadway. with Ghats
Rajbuha and Inlet heads, and
a 2nd Class Choki attached

7th Bridge at Roora
33 feet Waterway in 1 arch
18 feet Roadway. with Ghats
Rajbuha and Inlet heads, and
a 1st class Choki attached

8 Bridge at Tugalee
30 feet Waterway in 1 arch
18 feet Roadway. with Ghats
Rajbuha and Inlet heads,
and a 2nd class Choki attached

9th Bridge at Nurhaa
30 feet Waterway in 1 arch
18 feet Roadway, with Ghats
Rajbuha and Inlet heads,
~~connected with an Escape~~
~~of 4 feet Waterway~~ a 2nd Class
Choki attached.

10th Bridge at Akbarpoor
30 feet Waterway in 1 arch
25 feet Roadway. with
Ghats, Rajbuha and Inletheads
and a 2nd Class Choki attached

11th ~~Bridge~~ Falls and Works at Rubbipoor
~~30 feet Waterway in 1 arch~~
~~25 feet Roadway. with Ghats~~
Rajbuha

Similar to those in the Main, but has only 1 Chamber of 30 feet Waterway. Roadway of Bridge 25 feet broad. with 1 Class Choki situated in the Island in the usual position

~~Rajbaha and Inlet heads, and~~
~~a 1st Class Choki attached~~

12th Bridge at Koorai
30 feet Waterway in 1 arch
18 feet Roadway - with Ghats
Rajbaha and Inlet Heads and
a 2nd Class Choki attached

13th Bridge at ~~Daffiabad~~
26 feet waterway in 1 arch
18 feet Roadway - with Ghats
Rajbaha and Inlet heads
and a 2nd Class Choki attached

14th Bridge at Rhutgaon
26 feet Waterway in 1 arch
18 feet Roadway - with Ghats
Rajbaha and Inlet heads, and
a 2nd Class Choki attached

15th Bridge at Kawna
26 feet waterway in 1 arch
18 feet Roadway - with Ghats
Rajbaha and Inlet heads, and
a 1st Class Choki attached

16th Bridge at Khambi
26 feet waterway in 1 arch
20 feet Roadway - with Ghats
Rajbaha and Inlet Heads, and
a 2nd Class Choki attached

17th Bridge at
feet waterway in
feet Roadway - with Ghats
Rajbaha and Inlet Heads - and
a Class Choki attached

18th Bridge at
feet waterway in
feet Roadway - with Ghats
Rajbaha and Inlet heads, and
a Class Choki attached

19th Bridge at
feet waterway in
feet Roadway - with Ghats
Rajbaha and Inlet Heads, and
a Class Choki attached

20th Bridge at
feet Waterway in
feet Roadway with Flat
Rybuha and Inlet heads, and
a 2nd Class Choki attached
17th Escape and under Drain
at the 170 Mile similar to
that at Dubowli.—
18th Bridge at a point below
the Escape, One arch of 20 feet Span
with an arrangement for Regu
=lating. Similar to that at Dubowli
19th Locks and works ap.
=pertaining to the Summa
Terminus. vide Plate
XLVI of the Atlas.—

At this point we have
reached the Summa and the
Terminal Works ~~of that Line~~
Drawings explained in details the difference works
of the Etawah line; and having
passed in review the peculiarities
of surface, and the intricacies
of drainage, through which the
line of Canal had to pass in
its progress from Nanoon. ~~to~~
~~the Summa~~

As remarked in the Sum.
=mary on the Sister line to Cum.
=poor, I may observe that I have
persevered throughout the whole
of the works connected with these
Terminal lines to retain the pre.
=cise figures of Diagram XVII,
Figure II; leaving corrections
on actual measurements re.
=sulting

-sulting from work executed to be made afterwards; the difference can comparatively be small, whereas an alteration to the figures of the Table on which the Capacities of Channel and Value of discharge for Irrigation were calculated, would lead to unnecessary and useless trouble.

In referring to the Diagram above alluded to, it will be found that the supply for the Head of the Etawah Terminal Line which is estimated at 180 Miles in length is equal to 1640 Cubic feet per Second; the expenditure of this supply being calculated as follows:-

Britishers

Miles	Cubic feet per mile	
180 × 8 =	1440	Cubic feet per Second. for the use of Irrigation, as per Rules laid down in Table
	200	Cubic feet per Second, retained as a reserve supply for Navigation.

When drawing a Comparison between the Values of the Cawnpore and Etawah lines as means for irrigation, I shall enter more fully into the causes which have led me to design both the Channels and Works of the former on a somewhat larger Scale than those of the latter; it will be sufficient to observe here, that the supply which enters the Etawah line at Nunoon, will in its passage towards be liable to considerable diminution, especially at the early part of the course ~~of the line~~, from the draw

off

of of water which will be required for the country lying on the right bank of the Seyngoor, on which the Towns of Ferozabad, Etawah and Ooriya are situated. This supply will act in feeding ~~the Kol Branch which after passing through its calculated length of 50 Miles will proceed onwards in the form of a main Rajbaha for the irrigation of~~ the Country lying between the Seyngoor and the Jumna River —

The Cawnpoor Terminal Line looking at it as a navigable point of view, was considered to be of more importance than that running to the Jumna, and in making the Channel wider, the convenience of boats and Navigation in general was consulted —

In the progress of detailing the different works, I have given diagrams shewing the transverse sections of the Line at different points of its course. the value of discharge at the points where these Sections occur is shewn in the following Table. The width of Rectangular Section in I may observe having as a general rule been reduced by one foot, at the end of every 3 Miles. —

	Value of R	Value of $\frac{1}{n}$	Sectional area in Square feet	V in Feet	Discharge Theoretical	Discharge Required
1st Mile						
30th do						
65th do						
120th do						
121 to 150th do						

the Hatrass line of Irrigation under work runs the Bolundsh & Kol branches after their confluence at the point C (Diag. LVIII.) near the Town Hatrass proceed onwards for the use of

The variations of the slope of the bed are similar to those in the Cawnpoor line, although the disposition of that slope is somewhat different. From the Head at Nanoor, ~~15 Inches per Mile carries the water to the Bridge of~~ ~~the~~ ~~flowing of which there is a~~ ~~drop of Inches, from thence~~ the slope of 15 Inches is carried on to the 32nd Mile where a reduction of the slope from 15 to 12 inches takes place; in advance of the 32nd Mile, the slope of the bed is uniformly 12 Inches, until it approaches the Dumna, and comes within the influence of the Khadir lands connected with that River. X

~~As in the case of the last change of level in the Cawnpoor line, I have reserved at present from building locks, or providing for the passage of boats over the rapid formed by the depression of level, the probabilities of silt deposit being still greater here, than they are on the Cawnpoor line. Should the 3rd Mile of its course, and the change of level from 15 to 12 Inches take place at the 67 Miles, whereas in the present case there is only a distance~~

X Should the Ghat Fall at Mubbulpoor be noticed here?

~~distance of Miles between the two interruptions; at any rate I may observe here as I did when referring to the works on the Cawnpoor Canal, that there can neither be difficulty nor delay in making all the necessary arrangements for a Circuit round the rapids, should any anticipations of the kind be realized. And in the meantime, it would be wise as well as economical to refrain from extensive works, and defer the construction of works which may expend=itures, until we see the effects that will be produced by the admission of water.~~

The difficulties which were met with in the manufacture of bricks on the Cawnpoor line, have been equally felt on the Etawah one; the first 65 miles of the course of these two branches run parallel and with a sepa=ration of only 5½ miles of country between them. on this line, there=fore ~~was~~ their fields of operations very nearly the same, and the difficulties in obtain=ing fuel were greatly enhanced by the villages being common to both; the same inconvenience occured in the Kunkur Quarries, which had a double demand upon them by a draught for two different bounds of works as a general rule, however, material, both Brick and Kunkur, has been procured on this line

with

with less difficulty than it was on the other; but nevertheless we have here also been driven to the greatest economy in the use of Bricks, and to the adoption, as far as was possible, of Block kunkur, not only in the Bridges, but in the Choki buildings attached to them. This latter material has on the Etawah line of works been met with of a very superior quality fully equal, if not superior to that which is procured from the Bahosi Quarries in the Furruckabad District; that taken from the Quarries of Dussayn and which has been largely used in the Choki and bridge at Dao — is so compact as to be wanting in one of the most marked characteristics of kunkur, viz: its honey combed texture. Many of the blocks which have been used in the Pilkutra Bridge and which were extracted from the deserted ruins of Hindoo buildings in the neighborhood have on them Sculpture in deep relief carved on a surface as compact, as that of the Portland and Bath Oolite. The material is no doubt excellent, but as I have noted elsewhere, great discrimination is required in its use it is essential that the outer surfaces which are invariably

of

of a soft and very inferior &
texture when taken out of
the Quarries, should be care
=fully removed: and that in
laying the blocks in the build=
=ing, the horizontality of the
natural lamina should be
preserved, or more properly &
speaking, that the weight or
thrust should be brought to
bear on ~~its~~ their flat and not on
~~their~~ its end surfaces.

The design of the Bridges
is in every way similar to
that of the Chunnoor line,
the waterway being adapted
to the position in which the
bridge is situated; side arches
in prolongation of the towing
paths, keep up the line of com=
=munication on the berm level
and the plan and arrange=
=ment for Rybuha heads,
Inlets, Ghats and Chokies cor=
=respond in every way with
~~that which~~ those I have before de=
=scribed. —

The same remark applies
equally to the Escapes which
are built on the same plan,
and connected in the same
way with the Ghats and Bridge
works in their neighborhood
The rule in all cases has been
to avoid as much as possible
the separation of the works
and especially that of the
heads for Irrigation, Inlet or
Escape.

Escape from the immediate control and supervision of a Choki post. It will be observed that throughout the whole of this project, the Rajbaha Heads and Inlets by being designed as a component part of a bridge, become accessible from both sides of the Canal; the Es= =cape heads being placed in con= =nection with the ~~Regulators~~ Escapes attached to the Rajbaha Heads, lie under similar advantages, and the Establishment of a Choki post, by the construction of a + building sufficient for the ac= =commodation of the necessary guard, in the immediate vicinity, forming a part in fact, of the works, places the whole machine viz:. of Irrigation, Inlet and Escape under the immediate supervision and easy control of the Canal Establishment

The Heads of Irrigation are situated at nearly every bridge, (with modifications depending on Local causes) their dimensions being the same as those on the Cawnpoor line From the Head at Nanoor to the 30th Mile, or to the Bridge at Gubrana the width of water= =way is 10 feet, with its Sill raised 2½ Inches above the Canal bed From the 30th to the 90th Mile, or to the Budamyer Bridge, ~~the water= =way is decreased to 6 feet with its Sill raised to a height of 16 Inches above the Canal bed~~ From the 90th to the 150½ Mile the Waterway is retained on the width of 6 feet with its Sill raised 8 Inches above the bed of the Canal

Sill is raised only 16 Inches above the Canal bed, whilst the width of Waterway ~~xxxx

canal. From the 150th Mile to the Terminus; the Reaches are con=tinued on the 6 feet width, but their Sills are laid on the ~~level~~ level ~~as that~~ of the bed of the Channel.—

The Outlets or Escapes have been fixed as nearly as possible about 40 miles apart, and at similar distances to those on the Cawnpoor Branch; their Sites are at Gihnor, Mulhosi and Sithmuna:- the Escape which is connected with the Terminal works being considered as a por=tion of the works attached to the Lockage, and not coming under the Classification of a separate building.—

The views which I have entertained with regard to the postponement of the works on the Futtiguh, Bolundshuhur and Kool Branches, and to which I have drawn attention in a former Chapter, have inclined me to place the Terminal works of the Etawah line in abeyance; at least to postpone their exe=cution until the supply of water at the extremities of these long lines is more accu=rately understood and determined; this postponement may in fact resolve itself simply into a prose=cution of the works when the progress of operations arrive at that particular point, or to a delay of 2 or 3 years; but with the Example before us of the

Terminal

Terminal works on the Cawnpoor
line which are now under com-
=pletion, we shall be better able
to form an opinion as to the im-
=mediate necessity of forming
a connecting link for navigable
purposes with the Jumna, by
seeing how far the Canal sup-
=ply which for the first few
years will be comparatively
small, will act in maintaining
a head water on the lockage at
extreme points; the delay at
any rate in completing the
Terminal works on the Etawah
line will be beneficial, in enabling
us to act on most valuable experi-
=ence gained, without in any way
interupting the main object
of supplying Irrigation to the
Country. The delay, moreover,
will give us the means of col-
=lecting material in sufficient
quantities, to provide for an un-
=interupted completion of the
works, instead of carrying them
on by the hand to mouth pro-
=cess that has characterized
the progress of the Cawnpoor
Terminal works, which we have
an object in finishing off at
once.

I have proposed therefore,
that for the present the works
on the Etawah line should
terminate at the Bridge and
Escape at Sithmuna, or at the
14½ Mile of its course; the works
at Sithmuna are of considerable
extent and importance; they
will

will form a 1st Class Choki post,
and the residence there of the
Head Quarters of the Division
will enable the Executive En=
=gineer to collect material, and
to make arrangements for ulti
=mately completing the works
which are situated below it; &
Rajbuha Heads with their wate
ways of six feet in width and
with their Sills on a level with
the Canal bed, will be attached
to the Bridge at this point; &
that one on the left will pass
off the water for the temporary
supply of the country between
the Rinde and the Noon; whilst
that on the Right will afford
the means of Irrigation to the
Country lying on the west
of the Town of Ukbunpoor.
I use the expression 'temporary'
because on the completion of
the Canal Channel below the
Sithmuna bridge, the Rajbuha
Heads which are situated below
that and Ukbunpoor will add
their quota to the line of Raj=
=buha which passes on to
Ghatumpoor and Kora Juhan=
=abad.

On the subject of Irriga=
=tion generally I may observe
here as I have done elsewhere
that the lines of Rajbuha
will not be limited to the
Country between the Rinde
and Seymgoor: they will be
projected boldly across their
boundary

boundary Rivers wherever such may be considered expedient, the capacity of the Channel of the Etawah Branch has as I have before remarked been expressly designed, with a view of its Supply being considerably reduced on the first 100 miles of its course: the Rajbaha heads on the right, ~~being to be~~ converted into feeders for the ~~Hatras & line of Irrigation Etawah Branch~~, ~~which reduced to the Cawnpoor~~ =~~ma~~ =~~tra of a Mean~~ ~~base of~~ Rajbaha ~~up to the Junction of the Hatras line of Irrigation~~ ~~will pass between the Etawah~~ ^ ~~and the Cawnpoor, up to the junction of those two Rivers.~~

The design of the Chan= =nel with its berm, or towing path, its embankments, its Milestones, Plantations (both of fruit and forest Trees) and the single line of Mango trees for affording shade to the Roadway, is precisely the same on the Etawah, as it is on the Cawnpoor line. The Milestones are numbered in a consecutive series from the Nanoor Head to the Etawah Terminus, and the plinth of each Mile Stone is a bench Mark, or fixed point of level, the figures of which are engraved upon the Stone. The Roadway is formed on the left bank of the Canal similar to that on the Main and Cawnpoor lines, and its design both in width and Slope out= =wards is exactly the same

The accommodation for the Establishment

Establishment and for maintaining a line of Choki posts is precisely similar to that before described; and great care has been taken here as on the Cawnpoor line where the Country is subject to inundation arising from the slopes being insufficient to effect rapid drainage; to raise the buildings high above the Country, and to remove them as much as possible from the inconvenience and evil of dampness. To each of the 1st Class Chokies, buildings which are situated about 12 miles apart, a Mangoe graft plantation is to be ~~established~~ on the same scale as has been projected elsewhere.

I have at the early part of this Chapter explained that the whole of the Country which comes under the influence of the Tank's terminal line was subjected to a rigorous examination, borne out by numerous Cross and longitudinal Sections by Mr Dodsworth the Surveyor attached to the works. After testing Mr Dodsworth's Survey and proving most satisfactorily how correctly the work had been done; Lieut Whiting of the Bengal Engineers assisted by Lieut Johnstone of the same Corps commenced the works in the cold season of 1850/51. Since that period they have been in active progress, Lt Johnstone having been succeeded in 1852

by

by Lieut Brownlow of the Engineers; and Lieut Angelo of the 16th N. I. and Lieut Ipan of the 62nd N. I, additional assistants, having been attached since the Months of November 1832 and July 1833 respectively. — The State of the works in the beginning of 1834 was very far advanced. 60 Miles had been completed including both Earth and Masonry work; 50 Miles were in active progress, and I have no doubt that if my friend Lt Whiting's services are continued (which I hope they will be) until the whole is completed, the admirable system of Supervision which has enabled him to make such ~~Capital~~ Progress hitherto will secure its deserving recompense, in a consummation of the desired object in a period of 2 or 3 Years. —

CHAPTER. III.

Determination of the Alignement and Works on the Branches.

In the preceding Chapter I have endeavoured to describe in its fullest detail that portion of the Ganges Canal works, consisting of the main trunk, and the two Terminal lines into which it is separated at the Narroon Fork: the detail has necessarily been great, although not more so I hope than the circumstances of the case have called for; it has been founded on works actually completed, or at the time of my writing, in a forward state of progress; and the surveys and levels on that particular part of the Country over which the works are carried have been so elaborately executed, that the detail has not been interrupted by any points of obscurity, or by any want of information tending to embarras a narrative, which has had for its object the accurate delineation of the surface of the country and a precise statement of the works as actually completed, or in progress of completion. These remarks apply specifically to the main line of the Canal from the Head to the Narroon Regulators, and from thence to the

Left 15/53

the Ganges and Jumna Rivers on the Two Terminal lines into which the main Stream is divided.

The advantages above noted do not offer themselves in the subordinate lines of Canal which I am now about to describe, upon which the same time and labor in investigation have not up to the present period been expended. The preliminary Surveys although sufficient in themselves for establishing points and for marking the general direction upon which the alignements may be carried, do not enable us to describe with accuracy the courses upon which drainage in all its intricacies of detail tends to influence the practical carrying out of field operations; nor do they enable us to determine with accuracy the position of works, or the number of lines of cross communication which the wants of the Country may demand. On such foundations, we must be satisfied with a general programme, exhibiting in as much detail as possible the objects for which the branches are intended, and the best available method of obtaining those objects as derived from the data which are in our possession. The length of Channel, the general slope of the Country, and the Head supply of water being given, the capacities both for Excavation and Bridge water-

Sig 2 C. P. 385 —

ways

ways are easily determined; we are therefore restricted to these particular points. I shall, therefore, on the plan which I have previously laid down for my guidance enter into a description of the subordinate works above referred to. These consist of

I The Futtigurh Branch
II The Bolundshuhur Branch
III The Koel Branch.

I. The Futtigurh Branch

This is a Channel intended for the irrigation of the country lying between the East Kalli Nuddi and the Ganges River: its point of departure is situated at the 56th Mile of the Main Canal, near the village of Daoli in the Mozuffurnuggur District. The Head works are designed with Regulators both across the main Canal itself and the branch; a 1st Class Choki has been built in connection with these works, and the Station is one of the main posts on the Canal.

The theoretical Volume for the Futtigurh Branch is 124.0 Cubic feet per second, on an estimated length of 160 Miles of this length the 5 Miles at the head coming under the influence of the Irrigation from the

Main

5-928

main Canal have in the effective distribution of the above supply been deducted; the full theoretical volume being calculated for the Irrigation of the remaining 155 Miles, at the rate of 8 Cubic feet per Second per Mile.

It is proposed that the Futtiegurh Branch on its reaching the 160th Mile shall be continued onwards to the Town of Futtiegurh as a navigable Channel, so as to connect that place with the Main Canal, and thereby to give it the advantages of water carriage. Whether it may be necessary hereafter to build a series of terminal locks into the Ganges in the same way as has been done at Cawnpoor, may be at present doubtful; but at any rate as these are works demanding a large outlay of money, they may well be postponed until a future occasion. —

The preparatory Surveys required for the Futtiegurh Branch are in a more advanced State, than those of the other subordinate lines, the whole country from the main Trunk of the Canal at Dadoli to the junction of the East Kalli nuddi with the Ganges, has been surveyed and levelled by Mr Dodsworth, the series of levels consisting of a centrical or longitudinal line keeping as closely as possible upon the watershed, with transverse cross sections from River to River at

a

distance of 5 Miles apart. vide
Plate No VI of the Atlas. Mr
Read the Executive Officer of
the 2d Division of the works has
on Mr Dodsworth's map as a
ground work taken a proof line
along the watershed, thereby test
-ing the levels originally taken.
Mr Read the Executive has at
every mile on the leading 155
Miles ~~of its course~~ established
a Masonry Bench mark, and to
ensure the preservation of these
fixed points which indicate
not only the true levels but the
direction upon which the excava-
tion is to be carried, he has
raised over them Pyramidal
mounds of earth 8 feet in height,
to the repair and maintenance
of which his attention has been
directed. —

Mr Read reports "that
"levels have been taken at every
"400 feet apart closed upon the
"Masonry benchmark above
"mentioned and terminating
"at the 155th mile below the
"Headworks. From comparison
"with the plans of cross sections
"and Levels executed by Mr
"Dodsworth, this line of levels
"shews that ~~they have~~ it has been taken
"along the high ridge of the
"country through which ~~they~~ it
"runs, and is in every way ~~as~~
"favorable for canal purposes
"Beyond the point above
"alluded to (viz: that at the
"155th Mile) the levels and line
"have

"have still to be adjusted to allow
"of water communication with ~~between~~
"Fattigurh ~~and the 155 Miles of~~
"~~Canal~~, either by a Still, channel
"or otherwise as the nature of the
"ground and levels will admit of."

Mr Read adds "that Bricks
"have been made in sufficient
"quantities for the Masonry works
"on the first 20 miles of the branch;
"and for the next 20 miles ~~I have~~
"ascertained that an ample
"supply of Native bricks are
"procurable from different ruins
"in the vicinity, beyond this
"no arrangement for material
"has been made, but that at
"this point or near it commences
"a series of block Kunkur Quarries
"admirably adapted to building
"purposes; the localities of these
"Quarries have been carefully
"noted in the field Book, therefore
~~Mr Read remarks~~" the necessity
"for making bricks below this
"point (except for the purposes
"of arching) will almost be
"dispensed with. Earth Lime
"will have to be used for the
"first 40 Miles of the Works and
"a large supply of Marle for
"the Manufacture of this
"Material has been collected on
"the Main line, which can be
"carted to the Branch in suffi-
"cient quantities for each work.
"beyond this point (viz^t that
"at the 40^th Mile from the head)
"Kunkur lime will be used
"which is procurable in any
"quantity along the line."—

Although, therefore, for
reasons

reasons which have been before explained work has not been commenced upon on the Puttiginh line of Irrigation, all preparatory arrangements have been made with exception of the examination in detail of the surface drainage, and the final inspection of the line by the Director of the Works, previously to the commencement of excavation. —

Mr Read's profile of the Country to which he alludes in the above extracts from his report, will be found on the sheets of Mr Dodsworth's levels vide Plate VI, of the Atlas; On this profile I have projected a Channel with an uniform slope of 1·25 foot per mile, which leaves no less than 80 feet of superfluous descent; I have disposed of this in 10 masonry falls of 8 feet each, so that the amount of drop may be in uniformity with that on the Main Trunk line. The position of these falls is as follows: —

		Number of Regulating Sluices in each Fall	Width of Fall	Discharge	
				Theoretical	Required
		No	feet	feet	feet
1st on	11 miles	3	3	1058·76	1192
2nd on	18	3	3	1058·76	1136
3rd on	25	3	3	1058·76	1080
4th on	32	3	3	1058·76	1024
5th on	37	3	3	1058·76	984
6th on	55	3	3	1058·76	840
7th on	62	3	3	1058·76	784
8th on	79	2	3	705·84	648
9th on	88	2	3	705·84	576
10th on	119	2	3	705·84	328
	102	24	24	25	24

The Branch Head at Paoli has

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5. Area = 456
12
5472 +
89411 +
5472
547
219
49
4
R = 62.91 ✓

Perimeter
= 70 + 2×6√2
= 70 + √288
= 70 + 16.97056
= 86.97056
= 11498

63 3.38048
62 3.37696
.352 ✓
19
3168
35
3203
3.37696

62.91 3.38016
3.13679
.51695
3.288
.202
= 3.086 ✓

6 = 4224
42 .66212
147
.66359

6 = 4224
4200 1.78273
129
4224 1.78402
log 12 1.07918
2.86320
3.13679

63 12 2.429
.202

63
42
126
252
1449

537
42
1074
215
1289

2086 ×
654 ×
12344
1543
185
1407.2 ✓ — Dinch.

P. 389.

Area 426
12
5112
221
5112
1022
102
R = 62.36

△ 352
63
1056
211
1267
3.37696
3.37823
3.13679
.51502
3.274
.201
3.073 = V

Perimeter = 65 + √288
= 65 + 16.970
= 81.970
= 1/122

2429
2409
20
63
7.2
121 2.416
.201

3.073
624
12292
615
184
1309.1 = Disk.

III Area = 396
12
4752
29921
4752
4950
428
43
1
61.74

△ 357
47
2499
143
2642
3.37339
3.37603
3.13679
.51282
3.257
.200
3.057 = V

Perimeter = 60 + 16.970
= 76.970
= 1/1299 2

2.409
2.389
20
47
148
2389
12/ 2.404
.200

3.057
693
9171
2751
183
1210.51 = Disck.

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Area 366

12

4392

59831

4392

1318

351

39

2

61.02 ✓

△ 357

2

714

3.37339

3.37346

3.13679

.51025

3.238

.199

3.039 = ✓

=

Perimeter 55 + 16.970

= 71.970

= 1

13.895

2.409

2.389

.020

12 | 2.389

.199

3039

663

9117

18230

1820

11122 ✓ = Quick.

==

Area 336

12

4032

23941

4032

1613

363

12

1

60.21 ✓

△ 364

12

728

36

76.4

6 3.36975

3.37051

3.13679

.50730

3.216

198

3.018 = ✓

=

Perimeter

= 50 + 16.970

= 66.970

= 1

14.932

2.389

2.369

.020

12

004

12 | 2.373

.198

3.018

633

9054

905

1810

10140 ✓

==

P 389

Area = 276
12
3312
3555.71
3312
2318
166
17
1
58.141

376
41
376
150
526
58

3.336229
3.36282
3.13679
.49961

3.159
194
2.965 = V

Perimeter = 40 + 16.97
= 56.97
= 1/17533

12/2.329
.194

2965
672
5930
2076
178
818.47 = Disch.

Area = 246
12
2952
24291
2952
2657
59
12
1
56.81 √

390
18
3120
39
3159

335456
3.357772
3.13679
.49451
3.123
184
2.939 = V

Perimeter = 35 + 16.97
= 51.97
= 1/19242

~~12/3.308~~
~~292~~
~~276~~
12/2.208
.184

2.939
642
5878
11756
176
723.0 √ = Disch.

P. 389

Area = 216
12
2592
9212
5184
259
52
23
55.18
397
81
397
318
715
335095
3.355167
3.13679
.48840
3.079
189
2.890
2.890 = V

Per. = 30 + 16.97
= 46.97
= .
2129

2.288
2.267
021
81
4
12/2.271
.189

2.890
612
5780
289
173
624.2 = Dick

Area = 186
12
2232
72832
4464
670
178
4
1
53.17
411
71
411
288
699
334244
3.343314
3.13679
.47993
3.019
186
2.833 = V

Per. = 25 + 16.97
= 41.97
= '
23827

2.246
2225
.021
77
003
12/2.228
.188

2833
681
2833
2266
170
5269 = Dick

P. 389

Area = 156
12
1872
940 72
3744
1310
71
5062
△ 437
26
2622
87
2709
332960
3.33231
3.13679
.46910

2.945
181
2.764 = V
=

Perimeter
= 20 + 16.97
= 36.97
= 1
27049

2.182
2.160
.022
26
14
12/2.174
.181

522
26
132
4
136

2.764
651
2764
13822
166
4312 = Dijak
=

Area = 126
12
1512
97213
4536
151
30
11
1
47.291
△ 464
92
928
418
1346
331596
3.31731
3.13679
.45410

2.845
175
2.670 = V
=

Per. = 15 + 16.97
= 31.97
= 1
31279

2.116
2.093
.023
92
046
21
67
12/2.100
.175

2.670
621
2670
534
160
3336.4 = Dijak
=

has 4 waterways or bays of 20 feet in width each, each bay being fitted with Gates, for the regulation of the supply. For the design of this work Plate No: XXXIII of the Atlas which includes the whole of the works both of the main canal and the Branches at this particular point, must be consulted.

The capacity of the ex-=cavated channel is shewn by the following Table, the head supply being as before noted 1240 Cubic feet per Second, the slope of the bed 1·25 feet per mile, and the supply being supp-=posed to diminish as it ad-=vances in its course at the rate of 8 Cubic feet per running mile of Channel

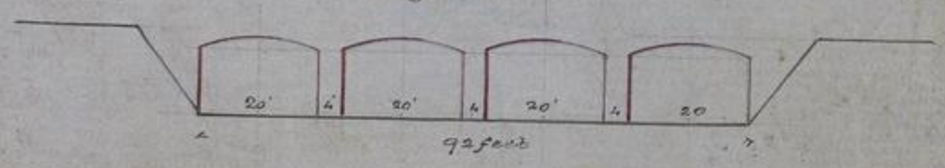
Depth of Water calculated at 6 feet.		Value of R	Value of $\frac{1}{6}$	Sectional area in square feet	V in feet per Second	Discharge per section	Discharge Required
Supply at the Head							1240
1	70' 10" Mile	62·8	$\frac{1}{1224}$	456	3·09	1409·04	1200
2	65' 20" "	62·2		426	3·08	1312·08	1120
3	60' 30" "	61·7		396	3·07	1215·72	1040
4	55' 40" "	61·0		366	3·04	1112·64	960
5	50' 50" "	60·2		336	3·02	1014·72	880
6	40' 70" "	58·1		276	2·97	819·72	720
7	35' 90" "	56·76		246	2·94	723·24	560
8	30' 110" "	55		216	2·894	625·104	400
9	25' 130" "	53		186	2·838	527·868	240
10	20' 150" "	51		156	2·783	434·148	80
11	15' 160" or 170" "	47		126	2·67	336·42	0

Sir Mc Brandon
& Andrews Hill

(1

At the Head which including piers has a section as follows.

Diag: LVI.

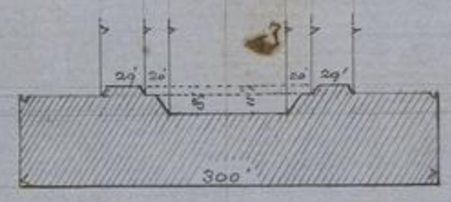


(2

the

the width of Excavation is 92 feet; the Channel in advance is 70 feet wide up to the 10th Mile as shewn in the 1st Section in the above Table. The general section of the Canal with its Embank=ments is as follows:-

Diag: LVII.



the width of Embankments as above shewn being considered a minimum one; From the 70th Mile the Vertical dimensions which up to that point have been 8 and 11 will be reduced to 6 and 8 feet, or in other words the Berm and Embankments will be 6 and 8 feet respectively from the Canal bed.-

The width of land between the Canal boundaries will be as follows:-

From the Head to the 10th Mile		300 feet
" 10th "	70th "	250 "
" 70th "	160 "	200 "

Up to the 70th Mile the dim=inution continues at the rate of 6 Inches per Mile or 5 feet in every 10 Miles

From the 70th Mile onwards the diminution is at the rate of only 3 Inches per Mile, or 5 feet in every 20 Miles of length of Channel

The dimensions of the Sections above given are so arranged that in advance of the 70th Mile the depth of water in the Canal which up to this point has been

6 feet will gradually decrease for instance

				Discharge	
				Theoretical	Required
On the 6th Inch in a depth of 5 feet is equal to a discharge of				619·875	720
7th	do	5 feet	do	545·6	560
8th	do	4 feet	do	334·576	400
9th	do	3 feet	do	178·5	240

Beyond this the Channel is excavated with regard to the emergent demands upon it in non Irrigating seasons, during the period of floods, and for the purposes of Navegation onwards

From the head to the 62nd mile in which the volume of water passing down the Canal will vary from 1240 to 784, I would maintain the Falls on one plan of opening, viz: 3 bays of 20 feet each, the value with reference to discharge is shewn in the Table above given; in advance of the 62nd mile, or on the 3 falls that are required below it, the waterways might be reduced to 2 Bays of 20 feet each. The Calculations on this front give a depth of 3 feet only upon the Sills of the overfalls which is equal to the average of the work that the falls on the Eastern Yamuna Canal have to undergo

For the purposes of Navigation each of these 10 Falls will require a lock Channel, and all its appendages, the design of which would be similar to that put in practice on the main Canal. —

Keeping to the plain of

of Navigation which would ultimately be adopted, I would in the Bridges maintain the flank passage for towing path communication, and even at the expense of additional length of wing, place them at a dis-tance ~~of not less than ten feet~~ walls removed from the inner side of the abutment.* On the main line of Canal these passages have in many cases been placed too close to the waterways, a cir-cumstance which, whatever may be the improvement to the eleva-tion of the Bridges is undoubtedly of no advantage to the commun-ication along the Towing Path, whilst it ~~brings the pas-sage into~~ any unnecessary ~~con-tiguity with the impost block of the Abutment arch~~.—

I would in the waterways of the Bridges confine them to bays of 25, 20, and 15 feet each; and supposing that lines of cross communication are re-quired at every 3 miles the works adapted to this purpose would be as follows:—

Miles		Waterway of Bridge	Width of Excavation as to Tables above
3	Bridge of 3 Bays of 25 feet each	75	70·00
6	Do	75	70·00
9	Do	75	70·00
11	Falls		69·50
12	Do	75	69·00
15	Do	75	67·50
18	Falls		66·00
21	Bridge of 3 Bays of 20 feet each	60	64·5
24	Do	60	63 0
25	Falls		62·5
27	Do	60	61·5
30	Do	60	60·0
32	Falls		59·0
33	Do	60	58·5
36	Do	60	57·0
37	Falls		56·5
39	Do	60	55·5
42	Bridge of 2 Bays of 25 feet each	50	54·0
45	Do	50	52·5
48	Do	50	51·0
51	Do	50	1.9·5
54	Do	50	48·0

* Note. In determining the position of the Towing path passages, the rule (alth deviated from in some cases) has been to place it on the outside & close to the intersection of the Tang of the Extrados of the main arch & the flooring of the passage. (vide Fig 2 Diag CXVII Part III Chap

I would extend this Diminution, giving an additional 2 feet to the width of masonry bet the main waterway & the inner side of t passage.

approximation to the impost blocks of the abutment arch exposes the work unnecess-arily to the consequences arising from careless & defective building

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Miles		Waterway of Bridge	Width of Excavations as per Table
55	Falls		47·50
57	Bridge of 2 Bays of 25 feet each	50	46·50
60	Do.	50	45·00
62	Falls Do.		44·00
63	Do.	50	43·50
66	Do.	50	42 00
69	Do.	50	40·50
72	Bridge of 2 Bays of 20 feet each	40	39·50
75	Do.	40	38·75
78	Do.	40	38·00
79	Falls Do.		37·75
81	Do.	40	37·25
82	Do.	40	36·50
87	Do.	40	35·75
88	Falls		35·50
90	Do.	40	35 00
93	Do.	40	34·25
96	Do.	40	33·5
99	Do.	40	32·75
102	Do.	40	32·00
105	Do.	40	31·25
108	Do.	40	30·50
111	Bridges of 2 Bays of 15 feet each	30	29·75
114	Do.	30	29 00
117	Do.	30	28·25
119	Falls		27·75
120	Do.	30	27·5
123	Do.	30	26·75
126	Do.	30	26·
129	Do.	30	25·25
132	Do.	30	24·5
135	Bridges of 1 Bay of 25 feet Span	25	23·75
138	Do.	25	23·
141	Do.	25	22·25
144	Do.	25	21·5
147	Do.	25	20·75
150	Do.	26	20·
153	Bridges of 1 Bay of 20 feet Span	20	19·25
156	Do.	20	18·5
159	Do.	20	17·75

Alder

The above would give in dependently of 10 falls:-

5 Bridges of 3 arches 25 feet each
7 " 3 " 20 " "
10 " 2 " 25 " "
13 " 2 " 20 " "
8 " 2 " 15 " "
6 " 1 " 25 " "
3 " 1 " 20 " "

The number of Bridges of cross communication in a total length of 160 miles would thus be 62. of which 52 would be plain Bridges and 10 bridges with ~~the~~ Falls attached

The details of dimensions of width of Roadways would be the same here as elsewhere viz:-

High Military Roads. 25 feet
Road Sind " 20 "
Village " 18 "

I consider the design for the Rajbuha Roads as adopted on

on the Main Canal, applicable in every way to the Branches, those at the Heads of the Masonry falls being similarly situated with regard to the Navigable Canal and the Locks; those at the Bridges being carried obliquely through the Bridge Ramps with attached Ghats and Inlets. As a rule I should say that for a distance of 6 Miles on the down stream side of a masonry fall and its attendant Heads for Irrigation the Bridges ought to be plain and without Rajbaha Heads, at such points, however, I would construct well Inlets, with Channels laid out on the same design as that where Rajbahas are used, in which case, the wells at the Ramp Angles which during flood season would act as Inlets, would at other periods provide access to the Canal water for the purposes of Irrigation.

All works attendant on the Embankments and provision for the accommodation of the Establishment, I would design uniformly with the Main Canal.

The details given for the Roadway, Milestones and Plantations ought to be the same and the Method pointed out for their maintenance, need not I imagine be departed from. A 1st Class Chokie at every 12 or 15 Miles, with 2nd Class Chokies at every Bridge to which Rajbaha Heads are attached would be sufficient for the accommodation

of

of the Establishment

Escapes ought to be established at a distance of 10 miles apart, the sluices being of the same dimensions as those elsewhere adopted. the widths of collected water way of each Escape ought to be rather in excess than otherwise of the Canal Channel at the point where the building is erected. At the extreme end of the Irrigating line, or at the 160th Mile, a work of this sort is proposed for the purpose of passing off the tail water. Eventually when the Branch is carried forward to Futtigunk for Navigation this escape will become a useful regulator of the supply, it ought I think to be made a capacious one, with 5 Sluices of 6 feet each in width

The want of detailed surveys of the superficial lines of drainage and hollows, which intersect the surface of the country over which the line of Canal runs will prevent my entering into a description of the subordinate cuts which will be required for relieving the Canal ~~bed~~ and the Country from intercepted drainage. The rule, however, which I have before adverted to, as that which has been our guide in the Main Canal works is, I believe, to be recommended, viz^t to draw away from the Canal alignement all intercepted water, and to carry it by artificial Cuts into the natural lines of drainage lying on the right and left

and left. —

The following tables will shew the surface levels of the Country at each 5 Miles in length of the course of the Canal as taken from Mr Dodsworths series of sections, the maximum and minimum depth of wells, i.e. the distance between the surface of the water and that of the earth lying in the neighborhood of each cross section is also exhibited. —

Numbers of miles from Head	Levels shewing depression of Country			Wells			Result of Cross Sections and Canal Line
	Left or Ganges	Centre or Canal Line	Right or East Kalli Nuddi	Maximum	Minimum		
							Miles
5	170.7.4	162.4.4	—	57.9.0	30.9.8	on Left of Bank of Ganges R	
10	167.6.0	171.9.1	177.4.8	51.5.0	22.0.0	do	12
15	189.0.0	182.5.6	194.7.7	42.9.0	22.6.0	do	12
20	204.6.9	198.0.0	212.2.6	48.9.0	18.3.5	do	16
25	228.7.8	207.3.3	220.7.6	47.11.5	23.11.0	do	14
30	228.3.6	225.2.2	232.7.9	35.11.0	25.7.3	do	13
35	240.5.3	230.0.5	244.5.0	38.11.0	12.2.6	do	17
40	250.0.5	236.9.4	255.0.1	38.10.0	22.4.0	do	15
45	298.6.7	251.3.2	260.11.8	32.6.0	22.2.0	on Ganges River	15
50	259.5.1	236.5.3	281.3.9	45.0.0	23.2.0	on Left of Bank	16
55	265.10.2	263.11.1	294.5.6	31.3.0	16.5.0	do	19
60	309.0.3	276.3.1	308.8.0	32.8.0	19.0.0	on Ganges River 13 miles thence on the East Kalli Nuddi.	27
65	314.10.4	286.8.2	316.3.6	39.2.0	27.9.6	on Ganges River	28
70	324.9.5	295.0.0	325.11.6	42.7.0	28.0.0	do	27
75	332.11.9	302.11.8	332.0.1	27.3.0	23.1.7	do	22
80	348.8.8	314.5.6	337.7.6	40.1.5	17.11.9	do	20
85	352.5.3	324.4.5	345.9.3	25.9.6	23.1.8	on Ganges River	15
90	362.3.2	331.9.1	350.5.4	36.1.0	18.0.0	do	14
95	371.11.1	340.7.5	365.10.9	26.6.0	12.5.1	do	20
100	374.11.9	349.11.3	376.0.4	32.0.0	13.4.0	do	19
105	381.5.0	367.11.3	384.7.5	29.5.0	33.10.2	on a Branch of Ganges	17
110	392.3.1	364.10.6	393.9.5	23.4.0	11.10.0	do	16
115	395.0.7	370.3.8	400.6.9	30.1.0	19.8.0	do	16
120	403.3.1	378.8.8	408.3.0	27.3.0	9.2.0	do	10
125	413.1.2	381.6.8	416.5.2	27.3.0	7.11.0	do	10
130	425.10.7	393.6.0	424.11.3	16.9.5	8.5.0	do	11
135	434.8.1	400.6.2	426.1.8	28.5.0	11.4.1	do	14
140	441.1.9	406.0.4	437.0.2	22.5.0	8.0.1	do	15
145	448.8.5	411.4.5	444.3.7	20.10.0	10.4.2	do	11
150	462.0.9	417.0.5	450.11.2	20.9.0	8.7.0	do	21
153	466.0.9	423.0.8	468.4.3	39.9.0	10.4.0	do	22
160	475.3.4	435.6.5	465.11.6	39.9.0	10.4.0	on Ganges River	21
165	479.3.1	437.11.4	474.2.0	19.7.0	7.5.0	do	21
170	485.11.1	444.8.9	477.6.5	35.3.0	9.8.0	do	23
175	495.11.1	450.9.9	485.7.8	37.2.0	9.2.0	do	28
180	502.3.7	461.9.0	493.9.6	46.5.0	25.4.0	do	20
185	508.6.9	464.3.4	500.8.9	34.8.0	22.5.0	Branch of Ganges	19
190	513.2.8	473.11.1	504.4.9	40.0.0	12.1.1	from Kalli Nuddi to Ganges River - Tullzuhl	14
195	519.3.7	479.4.7	516.1.0	39.1.0	14.8.0	do Kurmulgunj	7

Mr Read's line of levels upon which the benchmarks have been built, terminates at the 150th Mile, or at a point where the Surface of the Country is 427.20 feet below the Zero of the above Table: At the 160½ Mile, or at that point where the Canal Channel for Irrigating purposes terminates, the Surface of the Country will, I imagine, from the above Table of Mr Dodsworths, be 435.52.

From the above terminal point to the Town of Furruckabad the distance may be estimated at 21 Miles, and the level figure at that place is 476.63 feet. In 21 Miles therefore we have (to complete our channel as a Navigable line) to overcome a descent of 41.19 or nearly 2 feet per Mile Allowing .437 feet or 5¼ inches nearly per Mile we should require 4 Locks each with a dip of 8 feet, to connect the 160th Mile of the Futtiguhr Branch with the Town of Furruckabad, and 4 Locks more of the same dimensions to connect it with the Ganges River.

I Consider that the whole question of Navigation as it affects the Branch which we are now describing, is one that may well be left until its value as an Irrigating Channel has been sufficiently proved. In carrying on the works, therefore, I should refrain in the 1st instance from undertaking either the Locks and

Lock

Lock Channels round the Falls, or the excavated Channel and works for navigation beyond the 160¼ Mile. I should confine the works for the present entirely to Irrigating purposes, as per Estimate of 1850;- the Escape which I have proposed at the 160¼ Mile has, in fact, this object in view and the design laid down for the Canal Channel with its Towing Path, and the Towing Path Arches on the Bridge flanks will, by the mere addition of the works, the construction of which I would now postpone, render the branch a line for navigation.

The general slopes of the country from the Main Canal at Paoli to the 195th Mile, to-gether with those of the Ganges and East Kalli nudai Rivers, (the drainage boundaries of the strip of land which the Puttiguh Branch is intended to irrigate) will be seen clearly enough from the above Table, as well as by reference to Mr Dowsonth's Maps Plate No: VI of the Atlas. a few words on the direction of the Branch, as proposed by Mr Read, will complete all that I have to say on the works con-nected with this subject-

Mr Read's line on leaving the head at Paoli in the Mozuf-furnuggur District, proceeds on a direct course to the East of the village of Mowanna, the bearing is a few degrees to the

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the East of South and the distance 23 miles; at the 12th Mile from the Head, it enters the District of Meerut. On leaving Mowanna the direction runs for a distance of 23 miles almost due South to the village of Dutteeanna leaving the Town of Pureetchut-gunk on the West; The village of Dutteeanna is within a mile of the west of the line.

On the whole of the above course it keeps well clear of the heads of the East Kalli Nuddi which commence at the village of Untwana north of the town of Khutowli.

From the village of Dutteeanna the line has an inclination of about 20 degrees to the East, bearing in some measure upon the direction of the Ganges, so as to clear the heads of an extensive line of drainage which under the name of the Choiya commences almost on the right bank of the Ganges River, and flows into the East Kalli Nuddi on the boundary of the Budaon and Allygunh Districts. To avoid as much as possible the ramification of Nullas connected with the Choiya, and to escape interference with the hollows with which it is connected Mr Read's line in passing between Mullukpoor and the Ganges at Anoopshuhur, keeps as close as possible to the latter and for about 24 miles, in which distance both Anoopshuhur and

and Ramghat are passed, the
canal is separated from the high
bank of the Ganges by a distance
varying from 2 to 3 miles. As
the line proceeds onwards from
Ramghat it obtains a consider
-able departure from the Ganges
arising in a great measure
from a bend in the course of
the River, and reaches a point
about 3 miles west of the Town
of Deyoir in the Budaon District.
The total distance from Dattreanna
to Deyoir is 78 miles or thereabouts,
the early ½ of which are in the
Meerut, 50 in the Bolundshuhur,
21 in the Alligurh and 3 in the
Budaon Districts. That portion
of the line which lies in the
Bolundshuhur and Alligurh
Districts, and which evidently
comes in contact with the Choija
drainage, requires to be more care
-fully examined and reported
upon than it has been; the line
taken up by Mr Read is, I have
no doubt, the true one, but we
have as yet no accurate and
precise Map of the detail of the
cross drainage; which we ought
to have before our works are com
-menced upon; I would recom
-mend that the Choija Nulla
be surveyed from its Junction
with the East Kalli Nudai, upwards,
and that all the lines of hollows
into which it ramifies (in other
words that the whole of its Catch
-ment basin) should be care
-fully placed upon Paper, in
the same way as has been done

on

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on the Cawnpoor Terminal line on its approach to the Ganges.

On leaving Deyoa Mr Read's line continues for 31 miles on a bearing inclining to the East, leaving the Town of Putti-alla about 3 Miles on the left and terminating at the village of Bumar.- I am not aware of any remarkable Nullas or lines of drainage which would interfere with this part of the course of the Canal; Puttiala itself lies within a short distance of the old branch of the Ganges, parallel to and within about 1½ Miles of which the Canal would run.- It is possible that the Escape which is proposed to be made at the 160th mile or at the terminating of that portion of the branch which is intended for irrigation may be conveniently turned into one of the Ravines connected with the Ganges River: Of the 31 Miles above referred to, the 3 early ones are in the Budaon, 15 in the Mynpoori, and 13 in the Futti-gurh Districts.-

The Futtigurh Branch therefore, to which this Section is devoted, passes through the Dis-tricts of Mozuffurnuggur, Meerut Bolundshuhur, Alligurh, Budaon Mynpoori, and terminates in the Futtigurh District, to each of which within the limits bound-ed by the Ganges and East Kalli Nuddi it will afford the means of Irrigation; the 7th Column of the Table of levels which is above given, exhibits the levels of

of the country between the limits above mentioned: the Engines are dependant on Mr Dobsworths cross lines of section, which are not always at Right angles to the course of the Rivers, and may therefore be occasionally in excess; they will however be sufficient to shew the average width of the Strip of land which comes under the influence of Irrigation.

II and III *The Bolundshuhur and Koel Branches, forming the Head of the Ganges line of Irrigation.*

These Branches are so intimately connected with each other, that although they leave the Main line of the Canal at points separated by a distance of 42 Miles, the one in the Bolundshuhur, and the other in the Koel or Alligurh District, their projection, as the heads of of a series of uninterrupted irrigation, which extends as far as the junction of the Seyngoor with the Jumna, places them under one head, as portions of one great work. ~~for the purpose of Irrigation~~

With the exception of lines of Cross levels taken over the country, the Surveys of both the Bolundshuhur and Koel branches are (1854) incomplete. At the present time the

42.5

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the data upon which my remarks are founded, are a series of cross sections taken by Mr Volk between Bolundshuhur and Allignh; the sections extend from the last Kalli Nuddi (across the country over which the branches will be carried) to a distance of about 12 Miles to the right of the Kuroon River. they are carried in parallel lines at a distance of 5 miles apart. Mr Volk has also provided me with a longitudinal line of levels, ~~cussed~~ taken on the proposed course of the Bolundshuhur Branch for a distance of 46 miles; this longitudinal line terminates at the village of Rajpoor, from whence he has carried branch lines, one to the Puttwai Nulla which lies on the right, and the other to the Kuroon River situated on the left of the line. ~~upon which his levels were cussed~~.

As far as Mr Volks Survey extends the Profile is satisfactory but as ~~this~~ it consists of mere lines without reconnoissance or examination of the details of cross drainage ~~of the country~~ I have postponed further progress in laying out the works, until the topographical features of the Country through which the line of levels has been carried, are more accurately known.

In advance of Mr Volk's Cross Sections, which terminate at the

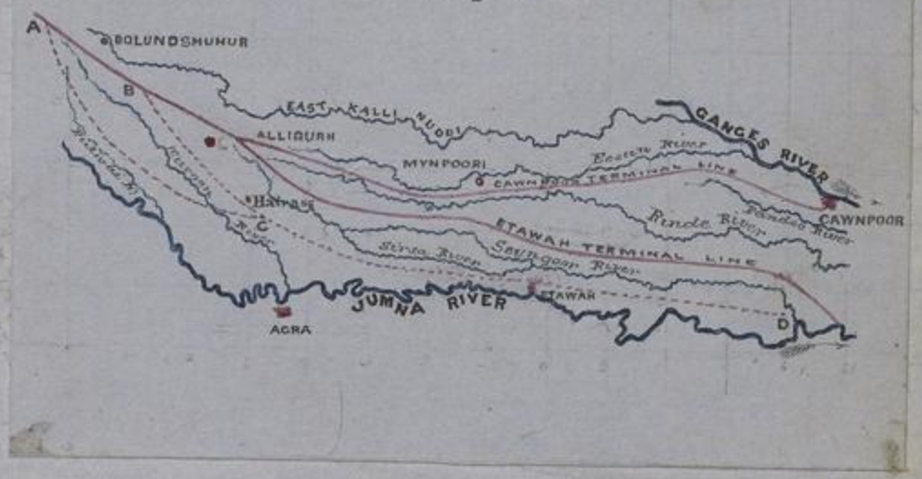
at the Town of Sasni, Mr:
Dodsworth's series commences on
a line taken from a masonry
bench mark or fixed point
established on a Tank near Kiel
due South to the Town of Ratias.
From thence the whole country
lying between the Seyngoor
and the Jumna Rivers has
been covered by a reticulation
of levels, consisting of a longi
=tudinal line running as
closely as possible on the water
shed, intersected at every five
Miles by a cross section between
the Two Rivers.-

As far therefore as a general
examination of the country by
Cross levels unaccompanied by the
details of subordinate drainage
is concerned, there are data
sufficient to enable me to arrive
at tolerably accurate conclusions
as to the general bearing on
which the lines of Canal will
be carried. The detail of works;
the precise position of the
Masonry descents for overcom=
=ing the superfluous fall in
the country; and the actual
line upon which the works
will lie ~~projected~~ traced, can only be de=
=termined after the country
has been surveyed in greater
detail.-

The plan of Irrigation
contemplated in the above se=
=ries, of which the Bolundshuhur
and Koel Branches are the os=
=tensible heads, is shewn by
the dotted lines in the follow=
=ing Diagram.-

Diagram LVIII

Diag: LVIII.



where AC and BC represent the Bolundshuhur and Koel Branches which uniting at the point C, in one channel proceed onwards between the Seyngoor and the Jumna Rivers to D

The design on which the original Estimates were framed was merely one assigning to each Branch a defined length of Channel regulated by the amount of Supply, ~~which was~~ considered sufficient for irrigating the tract of land ~~which would~~ coming under its influence. The detail of the works, and the direction upon which the Branches were to run, were left for future consideration, after the country had been properly examined

The length of Canal which was embraced in the Estimates was 70 Miles for each branch, with a Head Supply to each of 520 Cubic feet per second, the total amount of the Estimates for each Branch was (210 00 Rs) Two Lakhs and ten thousand Rupees; giving an aggregate of Four Lakhs and twenty thousand Rupees

Rupees for both works.

The extent, therefore, to which the Government works will be carried is equal to 110 miles they will terminate at the point C or at the junction of the two branches. In advance of the point C, a line of Rajbuhas which is chargeable to the Tuk-=kavi account, will proceed onwards between the Seyngoor and Purnna, terminating in the bed of the former River at D. This Rajbuha will pick up the tail water of the Bolundshuhur and Koel Branches after they have formed their junction at the point C and would be supplied on the first 100 Miles of the course of the Ganah ~~Branch~~ Terminal Line by feeders from that Line carried across the Seyngoor River.

The system of Irrigation above described makes a provision it will be observed for the whole of the Country lying between the main Canal and the Purnna River, and there is not a Section or Spit of land throughout this tract that will not be accessible by water courses. As far as I can judge by the relative positions of Points of Level as gained from Mr Walk's and Mr Dodsworth's Surveys, the area of Surface open to Ter irrigation, or to that where the aid of machinery is not required, will be unusually extensive.

The length of the works, into a description of which I am

about

about to enter is as follows;
using the round numbers of
measurement from a map,
which although not precisely
correct, will be sufficiently so
for my purposes.

AC Bolumdshuhun Branch - 90 miles in length
BC Koel Branch 50 do do
CD Main Rajbaha 160 do do

For the supply of these lines
1040 cubic feet per second have been
given, by Estimate, to the 140 miles
included in the Bolumdshuhun
and Koel Branches, and for the
remaining portion which is
considered under the Head of
a Rajbaha; an indefinite supply
will be provided by feeders taken
from the Etawah Terminal line,
for which provision has been made
in the Estimate for that particular
work.

It appears from the reduction
of Mr Walkis and Mr Dodsworths
levels, that assuming as the
fixed point C, or bench mark
established by the latter gentleman
at the village of Pykuduna, sit-
-uated three miles to the South
East of the Town of Patrass, we
have the following level points,
using the figures of the original
surveys:-

A - 225·69 Feet
B 279·56 "
C 348·51 "

The total declivity therefore on the
90 miles included in the Bolum-
-shuhun Branch is equal to +
122·82 feet, or on an average +
1·364 feet per Mile -

On the Koel Branch which lies in

in the above Diagram is represented as 50 miles in length, we have a declivity of 68·95 feet, or an average of 1·37 feet per Mile

The slope of bed which is proposed to be given to the above branches is equal to 1·25 feet per Mile. We have, therefore, in the case of the Bolimdashuhun Branch a superfluous or disposable amount of fall equal to 10·32 feet, and in the Koel line 6·25 feet, the whole of which must be provided for by masonry descents

I have in the description of the Country over which the main line of canal passes on its approach to the Alliginh from the Bolimdashuhun District, drawn attention to the sudden fall that occurs in the surface at that point. This sudden fall in the levels is on the main Canal met by 2 masonry descents of 5 feet each, which have been built at the villages of Pulra and Simra. The line of the Bolimdashuhun Branch, the head of which is situated near the village of Duhuna, at a point 39 miles above the head of the Pulra or Upper Falls, comes in contact it will be observed with this sudden change of level; the superfluous slope which is figured as 10·32, approximating as closely as possible to that which occurred on the main line. As an exhibition of this slope in as much detail as the valks cross sections will enable me to give it, and using the figures and measurements

of

of his Surveys, the following appear to be the results.—

	Fall Ft.	Rise Ft.
From the Head at Duhuma or from the 1st to the 5th Mile	6·01	
5th " 9½ "	14·14	
9½ " 13½ "	—	4·97
13½ " 17 "	4·23	
17 " 22½ "	4·48	
22½ " 27 "	18·18	
27 " 30 "	3·40	
30 " 35½ "	10·44	
35½ " 43 "	7·52	
43 " 48½ "	9·75	
48½ " 53 "	6·46	
53 " 58½ "	4·97	
58½ " 62½ "	9·68	
62½ " 69 "	10·15	
69 " 75 "	6·21	
Total Fall	115·64	4·97
Deduct Rise	4·97	
Total Fall in Surface of Country on 75 miles	110·67	

Pottsthier

the sudden declivity occurs between the 20th and 25 Miles

From the terminal point of the above series which is noted in the map as situated near the village of Soneyee, the fall to Mr Dobsworth's Benchmark at Pykwana appears to be 12·15 feet, the superfluous fall therefore lies between the Head and the village of Soneyee.

The Head of the Koel Branch is situated 3 Miles below the Pulra Falls; a portion therefore, of the superfluous slope which has been noted as attending upon the line BC has been disposed of in the Main Canal before the Koel Branch leaves it. The superfluous slope before noted may consequently be reduced from 6·45 to 1·45, and the only question that then remains is, whether there is any necessity for going to the expense of

of Masonry falls to meet such a small excess of slope, which, spread uniformly over the whole length of 50 miles, would merely increase the average from 1·25 to (1·254·029) 1·279 feet per mile. It is proposed however to carry this excess of slope on the prolongation of the Kael Branch from the point C to the 80th mile at Fergabad; now, as the Bolandshuhur Branch meets that of Kael at the point C on a reduced slope, the regimen of the beds after the influence of the two branches would be, to a certain extent Disarranged. The total amount of excess of fall in 80 miles is (80 × ·02) 2·32 feet. It is questionable whether with the given depth of section as shewn in Diagram LIX, it may be well to dispense of these inequalities of slope by masonry works; I am rather inclined looking at the subject in an economical point of view, to leave nature to make her own adjustments.

Pursuing the course adopted in the case of the Bolundshuhur Branch in giving the detail of levels as derived from Mr Volk's cross sections, the following is the result on as much of the Kael line as has yet been Surveyed. —

	Fall
From the Head at Gungowlee or from the 1st to the 6½th mile	6·66
6½ — " — 12½ — "	10·40
12½ — " — 18¾ — "	10·50
18¾ — " — 22½ — "	0·62
22½ — " — 29 — "	7·61
29 — " — 34 — "	18·73
Total Fall in Surface of Country on 34 miles	54·44

From the terminal point of the above Series which lies three miles South west of the Town of Sasni to Mr Dodsworth's Bench Mark at Pykowana the total fall is 14·61 feet, the distance being 16 miles; here also the excess of slope falls within the country between the main Canal and Sasni. —

I may observe with reference to the above points of level which are taken on an assumed line traced upon Mr Volk's map of his Survey; that the figures alone shew the necessity of further examination of the country, before the line of operations is actually determined on

on: for instance, attention is
naturally drawn to the profile of
the Country on the Koel line
as shewn by the Table between
the 6½ and the 22¾ Mile, in
which the hollows attaches to the
Seyngoor and Kunoor drainage
and the steppe in the surface of
the Country, depending on the
proximity to the Seyngoor, lead
to an irregularity in the disposi
=tion of the levels. This ~~Tract~~ without
an accurate reconnoitering sur
=vey, in which the different lines
of hollow are traced up to their
Sources, is fatal to arriving at
satisfactory conclusions as to the
true line upon which the branch
ought to be carried. There is
some obscurity therefore on this
point, which must be cleared
up by careful ~~after~~ investigation. ~~But~~
however
judging, from the Cross Sections
as shewn on Mr Volk's plan the
assumed line, appears to be
more adapted to the purpose
than that bearing on the high
=er levels near the Town of
Koel in which the exceeding
flatness of the Country would
lead to a depth of excavation,
~~that would~~ involving an expense,
greater in all probability than
that required for the artificial
disposal of the drainage else
=where.

I have before remarked, ~~how~~
~~ever~~, that it is essentially
necessary to have the lines of
drainage accurately ~~mapped~~
before the direction of the

Bolundshuhur

Bolundashuhun or Koel Branches is determined on.

~~I consider that~~ There is a great advantage in assimilating the proportions of works, especially those to which wood & Ironwork are approved. ~~ages of Wood and Iron work~~; For this Reason, I would divide the fall that occurs in the Bolundashuhun branch into 2 descents of 5 feet each, by doing which, the woodwork which is applicable to the falls on the main Towns would be equally appropriate to those on the Branch; by following this rule also ~~and~~ an uniform measurement for Sluice shutters, Sleepers, or lock Gates, would exist throughout the whole of the Division.

With the above preliminary observations, and the results of the level points as explained in the foregoing paragraphs, we possess data for the two branches which resolve themselves into the following - viz^{t}:-

I. The Bolundashuhun Branch with a Head supply equal to 520 Cubic feet per Second, with a slope of 1·25 feet per Mile, and 2 Masonry Descents of 5 feet each, for overcoming the superfluous fall in the Country. The length of this Branch being 90 Miles.

II. The Koel Branch with a Head supply equal to 520 Cubic feet per Second, with a slope of 1·279 feet per Mile, and with a length of 50 Miles.

In considering these two lines

lines as parts of one system of Irrigation, I shall adapt their supply to the lengths of their courses; throwing out the first five miles as coming under the influence of ~~the irrigation from~~ the Main Channel, and allowing 8 Cubic feet per mile as the supply required for the Irrigation of the Country through which it passes. Although, therefore, the waterway of the Heads is on one dimension, and although in the calculations for capacity of Channel I shall abide by the originally estimated discharge, I shall consider that each Branch is capable of carrying an additional volume; and that the Irrigation will not be interrupted by the occasional closing of one or the other heads, placing them under the same conditions as ~~are practised~~ exist on lines which are dependant upon two or more heads for their supply.

Agreeably to the terms above mentioned the actual ~~demands~~ supplies for the Country lying on the Bolundshuhur branch will equal.-

90 - 5 × 8, or 680 Cubic feet p. Second

whereas that on the Koel Line will be

50 - 5 × 8, or 360 Cubic ft. p. Second.

The waterway of the Heads both at Dulunna and Gungowli, is equal to 50 feet in width, and is therefore adapted to the discharge of the same body of water; the slopes

slopes of the branches being con-
=sidered similar.-

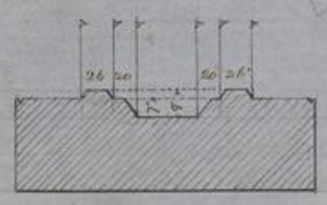
For the Excavated Channel therefore of the Bolundshuhur Branch we obtain by the formula which has been used throughout the Project for the Ganges Canal works, the following Table of dimensions.-

Depth of Section Calculated as 5 feet		Value of R	Value of $\frac{1}{6}$	Sectional area in Square feet	V in feet per Second	Discharge	
						Theor:	Requisite
30'	At the 1st Mile	51·00	$\frac{1}{422\frac{1}{2}}$	275	2·783	765	680
45'	" 10th "	50·70	"	250	2·783	695	610
40'	" 20th "	49·87	"	225	2·755	619	560
35'	" 30 "	48·80	"	200	2·728	545	480
30'	" 40th "	47·50	"	175	2·682	469	400
25'	" 50th "	45·93	"	150	2·641	396	320
20'	" 60th "	43·98	"	125	2·582	322	240
15'	" 70th "	41·15	"	100	2·491	249	160
10'	" 80th "	37·20	"	75	2·328	174	80

(3)

The general Section of the Channel is represented by the following Diagram, the width of Rectangle varying agreeably to the above Table, and the widths of Embankments depending on the quantity of Earth which is derived from the Excavation. The Section is in fact a minimum one with reference to widths of Embankments, and to the height from the Canal bed to the Embankment Tops.-

Diag: LIX.-



The Slopes of the Canal Chan-
=nel are 1 to 1, and those of the
Embankments

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Embankments 1½ to 1. The Berms to be carried on One uniform height of 7 feet from the bed of the Canal, or if this should involve an extraordinary expense, the system of gradual inclination on long lines, so as to make the higher and lower levels meet by an imperceptible change can be adopted

In the above Table it has been thought sufficient to give the Transverse Section at every ten miles in length of the course of the Channel: in carrying on the Excavation, however, the width of rectangle ought to be reduced to an extent of 6 Inches at the end of each mile, a proportion that will in practical operation be found convenient.—

In viewing the Koll Branch as the Second Head for the supply of an extended line of Irrigation, and as one liable to be charged with a volume of water Equal to that in the Bolundshuhur Branch; the capacities of both the Waterway at their Heads, and of their excavated channels having been designed on precisely the same dimensions; the detail given in the above table for the Bolundshuhur Branch is in fact that which is proposed for the Koel one, and although there is a slight excess of their slopes in the latter (the causes of which have been before explained) it has not been thought of sufficient moment to render alteration ne-

-cessary

-cessary.

In adopting the plan therefore, of assimilating the Koel Branch works to those of the Bolundshuhur: the latter it will be observed will meet and form a junction with the Koel line at the 50th Mile of its course, or at a point where the Excavated Channel is 25 feet in width. From this or the planting of the Hatteras line of Irrigation, point the dimensions will be reduced on the same scale as that shewn in the table. At the 80th Mile ~~or at a point~~ near the Town of Ferozabad the minimum width of 10 feet will be reached, and on these dimensions it is proposed to carry the line onwards for a distance of 85 miles to Oorya, From Oorya to the Seyngoor which is 35 Miles, the above dimensins might be gradually decreased to 3 feet in widths.

The Town of Ferozabad which lies on the 80th Mile of the direct course from the Koel Branch Head, is situated at a distance of about 17 Miles due South from the Etawah Branch in the vicinity of the Town of Moostafabad. The Etawah Branch has at this point passed the 45th Mile of its course, and is separated from Ferozabad by the Seyngoor and the Sirsa Rivers, the latter as I have before explained being a divided Stream of the Seyngoor itself which leaves that River near the North

boundary

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boundary of the Muttra and Agra Districts at a point about 12 Miles North West of Ferozabad

The Bolundshuhur and Koel Branches therefore, after their junction at the point C near the Town of Patrass, proceed onwards for a distance of 30 Miles with a capacity of Chan=nel equal to that of the Bolund=shuhur branch in the last 30 Miles of its course. Between Patrass and Ferozabad, the line runs parallel to and at about 17 Miles distant from the Etawah Branch, the Seyngoor and its drainage passing equi=distantly between them. On these 30 Miles it is proposed to establish 3 feeders from the Etawah branch, or 3 lines of Rajbuhas, the water of which will cross the Seyngoor on Sheet iron Channels. The width of the Rajbuhas and of these Channels need not exceed ten feet, but it is essential that in crossing the shallow depressions and hollows of which the Seyngoor in this part of its course consists, as little inter=ference as possible should be given to the free and un=impeded escape of the drain=age of the Country; flat tables laid upon Masonry Piers, ap=pear to be the most appropriate method for obtaining a maximum water way; and their efficiency has been proved on the Works for Irrigation connected with the

the Jumna.

I have limited the feeders which lie above the 30th mile of the Etawah Branch to three considering that the supply ~~of waterway~~ derived from 30 feet width of waterway will be ample, but the excavated channel of the Etawah Branch is calculated ~~for the supplying~~ six feeders to the Natrus line of Irrigation on the first 100 miles of its course; so that considering that these feeders act as the supplies for Irrigation to the country through which they pass, it appears to be a matter of indifference in how far they are multiplied, as long as the expense attendant on their passage of the Seyngoor is economically considered. The position of the Seyngoor River however, naturally leads to these considerations, and it becomes an object to restrict the number of aqueducts within moderate although efficient limits. With this view a feeder might be established at every 10 miles or at every third Bridge of the course of the Etawah Branch It is needless however, to speculate on points which experience will soon simplify; it is sufficient for our purpose that the relative position of the 2 lines provides ample

means

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means for their accommodating themselves to each other.

From the junction at the point C, down to which the bed slopes have been determined on levels taken by Mr Volk connected with Mr Dodsworths Bench mark at C; the following table will explain the slopes of the country from the point where the Bolindshuhun and Koel Branches unite to the Seyngoor River at the point D. assuming the point of junction near Nattass as the 1st Mile.

					Fall Ft.	Rise Ft.
From the	1st	to the	4 3/4	Mile	3·00	
"	4 3/4	"	9 3/4	"	1·97	
	9 3/4	"	15 1/4	"	7·68	
	15 1/4	"	20	"	5·49	
	20	"	25 1/2	"	3·75	
	25 1/2	"	32 1/4	"	11·00	
	32 1/4	"	38 1/4	"	3·60	
	38 1/4	"	43 1/4	"	6·36	
	43 1/4	"	48 3/4	"	—	0·44
	48 3/4	"	54 1/4	"	11·11	
	54 1/4	"	59 3/4	"	6·12	
	59 3/4	"	65	"	2·44	
	65	"	70	"	4·08	
	70	"	75 1/2	"	7·20	
	75 1/2	"	80 3/4	"	10·09	
	80 3/4	"	87 1/4	"	2·99	
	87 1/4	"	92 3/4	"	5·44	
	92 3/4	"	98	"	4·40	
	98	"	103 1/4	"	3·33	
	103 1/4	"	110	"	6·90	
	110	"	114 3/4	"	3·57	
	114 3/4	"	119 1/4	"	7·10	
	119 1/4	"	125 3/4	"	5·56	
	125 3/4	"	130 3/4	"	4·65	
	130 3/4	"	136 3/4	"	3·44	
	136 3/4	"	143	"	8·34	
	143	"	148 1/2	"	9·27	
	148 1/2	"	154	"	2·93	
				Totals	151·81	0·44
				Nett Rise	0·44	
Total Fall in Surface of Country from the junction of the Bolindshuhun and Koel Branches to the junction of the Seyngoor with the Damuda					151·37	

In examining the above Table

we find that

On the 1st 20 miles the total amount of fall is 18·14
" next 50 " do do 48·02
" next 40 " do do 40·35
" remaining 45 do do 44·86

The average fall, therefore, on the whole line as shewn by points in Mr Dodsworths levels does not give 12 inches per mile, which is somewhat less than the parallel line of the Etawah branch.

From the last Station noted as the 152nd mile, which is situated close to the Ravines on the right of the Seyngoor, the Etawah Branch, at a point near Sirinuggur, is 12½ miles distant. The Station point at Sirinuggur is 15·58 feet below that of the 152nd mile; these Stations however are separated by the Seyngoor River which runs through a deep Channel bounded on both sides by a labyrinth of huge Ravines ~~which occupy~~ ^ lodged by more than half of the width of Country that separates the two points; ^ is occupied the region is an intractable one, uncultivated and uninhabited. The Town of Moosanuggur lies at the distance of 7½ Miles South East of the Station at the 152nd mile.

As far as the data with which we have been provided enables us to form an opinion we shall be able to obtain slopes for the beds of these lines of irrigation quite sufficient for every purpose. Those of the Bolundshuhur and Kuel branches

up

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up to the junction, being 1·25 and 1·279 respectively; and that from the junction being 12 Inches throughout its whole course. The supply both from the Main Canal and from the Etawah Terminal line will be adequate to maintain a sufficient volume of water in the ten feet Channel which runs from Ferozabad to Oorya, and with proper regulation at the heads, and with ~~proper~~ adequate means of escape, there appears to me to be no reason why this, altho' a very extended line, may not prove to be a very efficient one

With reference to the Escapes and works which have been designed for these branches, I would refer to Sheet XLVII of the Atlas, which contains general designs for all the different species of works that may be required on the subordinate lines whether of Branch, or of Rajbuha. —

Before closing my remarks on the above line of Irrigation which I have designated 'the Patrah', from the Town of that name which lies at the point where the two main Branches from the Bolundshuhur and Koel Heads form a junction, it is necessary to advert to the means of Escape that must be provided not only to relieve the works from flood water during the rainy months, but to provide for exigencies of super-abundant supply, which from the circumstances of the two Branches terminating in

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a Canal of comparatively speak=ing smaller dimensions will in all probability be frequently necessary.

Both the Kunoon and Seyn=-goor Rivers as far south as the Region of Hatrass, are by no means capable of acting as the receivers of waste water, their beds are depressed below the level of the Country to a very moderate extent, and their Capacities of Channel, are small; The Seyn=-goor River lies between the Etawah Terminal ~~line~~ and the Hatrass line, and will be crossed by numerous Aqueducts which would interfere more or less with the Channel under a supply in excess of that of the natural drainage of the Country

The Kunoon River will be crossed in the neighborhood of Hatrass by an Aqueduct for the uses of the Bolundshuhur Branch, it would therefore, be unwise to load the Channel of this River at any point on the up stream side of the Aqueduct with additional water.

Above Hatrass, therefore, or above the junction of the two branches, both the Kunoon and Seyngoor have been considered unavailable as lines for Escape, and consequently the Koel Branch from its head to its junction has no Escape whatever, further than that which may be provided by the Rajbuhas or lines of Irrigation on its right

and

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and left. ~~Lunka~~

The Bolundshuhur Branch which may be considered the leading one as connected with the Ratras Irrigation at a point about ten miles from its head at Duhuna crosses some low land lying under and to the North of the Village of Kot. This low land which lies to the westward of the Town of Jarcha is the head of a line of nulla which, under the name of the Putwai, enters the Khadir of the Jumna, and joins that River to the South of the Theel and Town of Nooh. The total length of the Putwai Nulla from its source to the Jumna is about 52 Miles. Mr Volk observes that "from "the Theel near Kot to the Village "of Rumhera, or in a distance "of about 35 Miles no regular "River bed is formed, and cul- "tivation is carried on in the "slight depressions occupied by "water at the time of very heavy "rain. Close above the Village "of Rumhera the Putwai Nulla "is joined by another line of "drainage collected in the ex- "tensive Dâk Jungle lying be- "tween Dunkour and Ruboorooa "After the junction of these two "lines a regular Nulla is formed, "which increases in width un- "til it joins the Jumna, severa "Miles below the Nooh Theel "in the Mutra District."

It will be understood from the above description of the Putwai

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Putwar Nulla which runs parallel
to and on the right of the Branch,
that as far South as the Village
of Rumbera, it offers no facilities
for Escape; at the village of
Rajpoor, however, and at a
point situated at the 6th mile
of the line laid out by Mr Volk
a series of levels carried to the
Putwar Nulla under the village
of Barote, shews a depression
of 30·9 feet in a distance of
7 miles, the actual section of the
Nulla at this point being 15 feet
wide and 2½ feet deep:- Here,
therefore, a leading head for Es-
-cape might be established,
and I would, as the section of
the Branch at this point will
be about 27½ ~~Feet~~ wide, in-
-dependent of Slopes, give a
water way to the Escape equal
to 30 feet, or five Sluices of 6 feet
each. At the point where the
Branch crosses the Kurroor
River a similar Escape would
render the Bolundshuhur line
complete, and enable the sup-
-ply which is received from
Dalhuna to be held in perfect
command. In addition to
the two Escapes above mentioned
which would be specifically
for the relief of the Bolundshuhur
Branch, an Escape with a
water way of 30 feet with 5
Sluices of 6 feet each, ought to
be placed in the neighborhood
of the Town of Sukpoo, or at
some point immediately below
the

the junction of the two branches, the Escape Channel would be carried into the Kunoon River and it would act during the dry weather as a regulator under the contingency of accidental over supplies of water, coming down the two Branches; during the rains it would in all probability afford the most serviceable relief at a point where such relief is most particularly needed.—

It is needless to attempt, under the imperfect knowledge of the detail of the country which I possess, to fix upon precise spots for escapes from the junction to the Terminus at the Teyngoor River; the line, however runs parallel and in many cases close to the Ravines which skirt the Jumna, all of which are available as receptacles for Escape water. Again, as the Teyngoor River advances in its course, its channel becomes more capacious, and from the 60th Mile or from the neighborhood of Gihror, it is applicable at any point for receiving any supply of water that might be thrown into it. I would however in fixing upon sites for Escapes consider that a distance of 40 miles is sufficient between each, and that the waterway should be divided into sluices of 6 feet each in width and be rather in excess than otherwise to the width of the

Channel

channel at the point where the Escape is situated. — Where the fall between the bed of the Canal and the bed of the Nulla or River into which the Escape runs, is very great, it is at all times advisable to protect the Channel from retrogression of Levels, either by permanent Masonry works, or by the application of any species of heavy material that may be at hand. — The evil of retrogression of level upon the Canal Channel is one of such magnitude, that I would prefer, as a general rule, selecting points for Escape at some distance from the Ravines and Khallis of the large Rivers, or, in fact, were such possible, having nothing to say to them at all; this, however, is unavoidable in many cases; it has been so in our Escapes to the West Kalli Nuddi, on which expensive Masonry works will be ultimately required to prevent the levels from retrograding upon the Main Canal; and on the line now under review, it will be equally unavoidable as the only available receptacle for Escape water are the Ravines of the Dumna Khallis and of the Teyngoor. —

In conclusion, I may observe that in the design for these, as well as in that for the works on the Main Canal, the demands for navigation, as well as for Irrigation have been con-

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-sulted. The Falls or Masonry descents will be passed by a navigable Channel fitted with Locks on the same plan as those on the main Trunk line; the Bridges, Towing paths, and the detail of the Masonry works generally will be adopted to Navigation, so that rafts or boats may reach ~~to~~ every point to which the main lines extend. It may possibly be a matter worthy of consideration hereafter, whether by combining an Es=-cape with a navigable Chan=-nel, taken from the Bolundshuhur Branch near Belas-poor to the Jumna River, two good objects may not be attained. 1st The means of providing relief during floods; and 2nd, the means of connecting the main Canal with the Jumna by a navigable line at a point just below that where the Hindun River joins it. This line might perhaps be more favorable for navigation than that which I have sug=-gested as leaving the main Canal near Moradnuggur and joining the Hindun near the Ghaziooddeennuggur Bridge. In the former case the connection with the Jumna would lie on its whole course by a well regulated line of canal; in the latter the greater portion would be occupied by the tortuous course of the Hindun River. Mr Volk's levels from the

the surface of the Country at Belaspoor, to a Nulla lying in the Khadir near the main River shew that on a line of 8 Miles the fall is equal to 47 feet.— Belaspoor is a Jaghire belonging to the late Colonel Skinner; whose sons now hold it in hereditary right from their ~~late~~ distinguished Father.—

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P. 571 in continuation of Text

Before closing this Chapter I may, in ~~proceeding~~, draw attention to the imperfect data upon which the estimates for the Branches had necessarily to be formed. In the ~~imperfect knowledge of the details of surface and extent to which the resources of the Land Customs might be applied~~ This will be gathered from the opening Paragraphs of this Chapter when explaining that even at the close of my reports in 1853/54 I have been unable to lay down the same definite views as to detail that accompanies my description of the main & Internal lines. Since the period to the Statistics now drawn up much information has been obtained not only of the proposed portions & contour of the but of the Demands & resources of those objects the branches take their course. The Country in all its successive Thus information may daily develope in the detail has at every step given increased confidence to the views which I had formed, as to the value of these subsidiary works, whether the increase of enfeeble may thereby be / and in that of the Portuguese Branch if my views are carried out, they will be seen / this increase will be made by a proportionate return to the outlay expended, and by increased benefit & encouragement to the trade & agriculture of the Country.

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PART II

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CHAPTER, IV.

Description of the System of Distribution by Rajbuhas, or main Lines of Water Course

The term "Rajbuha" is the only one, which has been left to us by our native predecessors, as distinctly attached to irrigation. On the Delhi and Hansi Canals, or those which are now designated the "Western Jumna Canals", the country ~~in their neighborhood~~ was marked by extensive lines of mound or Embankment the origin of which was hardly understood at the period when with a view to the restoration of the Canals, which had for ~~upwards~~ nearly of a century been deserted, the half obliterated Canal Channels were ~~examined~~ traversed by the British Surveyors. A Cut or watercourse for the purpose of irrigation naturally implies a hollow or an excavated Channel, and it was difficult in the existence of these long lines of Elevated mound, to recognize in them the remains of ancient lines for Irrigation; Such, however they undoubtedly were, and the peculiarity of form merely depended on the weathering of the collections of Sand and Silt deposits with which they had been incumbered. - The constant necessity for the removal of deposits, was in all probability as

as great a source of expense and inconvenience to cultivators in those times as it has been to us. The lines of Mound above alluded to have at this period their representatives on both sides of the Punna, where the desertion of recent water courses after a few years occupation leaves a trace similar in every respect to that of the ancient Rajbuha

It was the non existence of these old traces of water courses on the country through which the Eastern Punna Canal takes its course; that led to the supposition that this Canal in its ancient state had either not been used at all, or had only been partially applied to the uses of Irrigation; they were numerous and appeared as remarkable features on the western side of the Punna, whereas on the Eastern side they were unknown; the inference therefore that the Engineering difficulties which had interfered with the maintenance of a continued supply* in this Canal had led to its failure in the original conception was borne out

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* There are traditions of serious damage having been caused to the Towns of Behut and Saharunpoor by the opening of this Canal by Zabita Khan, and it is possible that both in this case as in that of the original project, the difficulties of maintaining a passage over so many Mountain Torrents led to the works being abandoned. It is however perfectly clear that no great quantity of water could ever have been allowed to run for any lengthened period of time: the excessive dip of the country between the Nogong and the Muskuna Rivers would have led to a retrogression of levels fatal to the works. No Masonry works of any description were discovered, and altho' traces of Excavations were found in the nearer District, it may be fairly doubted whether the Canal was reached so distant a point

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~~As the old mounds in the Delhi and adjoining Districts~~ had in the traditions of their inhabitants been handed down from Father to Son as the remains of "Rajbuhas", this name was assumed by us, although perhaps with a more specific application.

To illustrate the relation of the Rajbuha to the Canal itself in the system of Irrigation adopted in the North West Provinces of India in a manner which will be familiar to most readers, the details of the method of supplying the population of Towns & Cities in Europe with water may be referred to. In the latter the water is collected in the reservoir from hence it is carried to the outskirts of the Town in the 'mains' or great supply pipes: from them it is led through the different streets in the "Distributary pipes" and the wants of individual houses are met by a system of "Service pipes". Now in our Irrigation system, the Trunk & Terminal lines with the great branches play the part of the Reservoir: the Rajbuhas hold to them the relation of "Distributary pipes" and the village water courses represent the 'Service pipes' in the disposal of the supply in detail. The Rajbuha is thus the connecting link between the supply & the service channels & it is from it alone that the process of distribution is carried on;

out in a measure by the absence of all traces of ancient watercourse.

had in the traditions of their inhabitants been handed down from Father to Son, as the remains of "Rajbuhas", this name was assumed by us, although perhaps with a more specific application.

The "Rajbuha" in the System of Irrigation adopted in the North West Provinces of India, bears in relation to the Canal itself, a position similar to that of "the main pipes" of Reservoirs for the supply of water to the population of Towns and Cities in Europe, it is the link between the Reservoir head of supply, and the small pipes for its distribution amongst the Inhabitants. Whilst the main canal and its Branches, therefore, perform their duties as the reservoirs for maintaining a supply, the Rajbuhas which are taken from them, act as the Main pipes, from whence the Village water courses are taken, and from which the fields are supplied with the means of Irrigation. It is from the Rajbuhas alone that ~~the distribution is detected of water is effected and consequently~~, the success of this distribution depends upon the judicious lining out and adjustment of their heads and Channels, with reference not only to the command of water as derived from their sources but

but to that over the country which they are intended to irrigate. The Rajbuhas again are private property executed at the cost of the Irrigators, and although their execution, their superintendence, and their maintenance in a state of repair, are the specific duties of the Government Establishments: these duties have been imposed at the desire of the community, Government having no claim upon the works of any description.

From what has been said before of the general design of the works on the Ganges Canal, and the position that they hold with reference to the slopes of the Country, it will be understood that this position is uniformly on the summit levels, or on the watershed of the different Sections or Spits of land into which the Doab is divided, by the different Rivers which constitute its natural drainage. Taking therefore the main Trunk from Hurdwar to the point of separation into its two Terminal lines at Nanoon; and considering the position of these two lines, as well as that of the subordinate ones which (under the designation of the Futtigunj, the Bolundshuhur, and Koel Branches) have been constructed as sources of main supply: we have as a leading feature in the proposed system of Irrigation, an extended series of reservoirs, adapted to the purposes of providing water by the

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the agency of as many Rajbahas as the exigencies of the land requiring irrigation may call for.

With a provision of Reservoirs as above explained, the method of distributing water, simple as it may appear in a general way, has demanded much consideration. The mere laying out of the Rajbahas, is, in consequence of the interposition of Rivers, and their proximity to the main lines of Canal in cases where the water-shed impinges upon them, a question not altogether free from perplexity; but this is of minor consideration when placed in juxtaposition with that of the best method of distributing the water to the Irrigators, of equalizing this distribution, and of determining a measure, by which the quantity of water and consequently the value of the water supplied, can be adjusted.

This adjustment is by no means difficult where, as in the Canals in Upper Italy, the height of water in the Reservoir or in the main Canal remains constant, or nearly so; where the water is free from impurities, and where the slopes of the country are considerable: with such propitious elements, the Italian Engineers have established after Eight Centuries of practice in Irrigation a measure or module, which enables them by the application of a very simple and at the same time

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a very ingenious water course head, to supply water by mea=
=surement, or by a certain amount of discharge the unit of which has been determined. Both in Lombardy and Piedmont how=
=ever, the value of this unit varies with the locality of the Irrigation; up to the present period there is no fixed standard, nor are the details of the different parts of the structure which has after so long a period been accepted as the most perfect, similar in different districts. The module in fact, is still capable of im=
=provement; ~~that of Woolaston~~ ~~which in the neighborhood of~~ ~~Milan, I inspected in many~~ ~~cases, is as little to be compared~~ ~~to the theoretical mechanical~~ ~~=ness in Bruschetti's and~~ ~~Bidault de Bufons estimates,~~ ~~as a rough hewn plank is to~~ ~~a magnificent table.~~ Practically speaking the Machine in use, appeared to me to be roughly built, and the parts not put well together; my impression was that were the supply heads in general, similar to those which came under my inspection; their value, as measures of water, each of which represents a fixed value in money has been overestimated. It appears to me also that the object of protecting the interests of the buyer and seller (supposing that the principle on which the machine is designed is perfect) could only be obtained by a more carefully built structure

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structure, and by the provision of more careful superintendence than appeared to be given to it.

On the Canals of Irrigation in the North West Provinces of India, the elements which I have before referred as so favorable to the success of the Italian Engineers, are altogether wanting. On the Ganga Canals, for instance, the absence of uniformity in the surface level of the Main Canal or Reservoir is remarkable; the water is loaded with impurities in the shape of sand and silt; and the slopes of the country, although rapid in the Northern Districts, are in the Southern, and in those where the greatest extent of Irrigation exists, comparatively small.

This is not the place to enter into a description of the Italian module; although to shew its difficulty of application on Canals laboring under the impediments above described, it is necessary to point out that the efficiency and, in fact, the whole use of the Machine as applied to the purposes for which it was invented, depend entirely on a free and uninterrupted flow of water away from it: obstructions dependent on want of slope at the tail, or on deposits of sand, would be fatal to the uses of the Machine, so that laying aside the want of similarity between the Ganga and the Italian Canals in other respects; the impurities which exist

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exist at the present time, and which have existed though in a greater degree during the early periods after the Eastern and Western Jumna Canals were opened, are not only a great bar, but almost a prohibition to the establishment of apparatus for regulating the discharge from the water course heads. I may remark here, however, that in the valley of Dehra, the Canals, small as they are, are free from all the evils to which those on the Jumna are liable. They possess all the elements requisite for the application of measuring apparatus, and from the shortness of their courses, the water runs on depths more uniform than it does on the longer lines of the Canals attached to the Jumna.

Up to the present period, the method of distributing water from the Canals in the North West Provinces, has been partly by village water courses taken directly from the main line or its branches, and partly from Rajbuhas; the former and the most objectionable method has almost entirely given way to the Rajbuha System on the Eastern Jumna Canal, which has been carried out to the utmost extent possible, and with extraordinary advantages to the Cultivators. On the Canals west of the Jumna, where the slopes are not so favorable to the connected series forming a Rajbuha

System

systems, main lines ~~of boats~~ Courses or Rajbahas have as fre=quently as possible been substi=tuted for the village water courses, but the extension of these main lines does not make rapid pro=gress, one great cause of which is the frightful deposition of sand and silt, which cannot be got rid of, until the slopes of the main Canal which in parts are those of a natural river, are modified.

Neither in the case of the Rajbaha or village water course head, is there any further arrange=ment for regulating the supply than the intervention of planks or shutters for opening and closing them: in many cases where the village water Course head is taken direct from the main Canal, the depression of a foot in the high water mark, leaves the head high and dry, and universally the sand deposits, which although common to all, are more certain at the heads of those lines through which there is no constant cir=culation of fluid, render clear=ances at very short periods con=stantly necessary. Up to the pre=sent time, in fact, the method of distributing water from the Canals in these Provinces, has with the exception to the system of Rajbahas established on the Eastern Jumna Canal, owed as little to science as possible; it commenced in the year 1819 when the first Canal

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was opened, and has continued up to the year 1853, much in the same fashion.—

Irregularity in the means of distributing water, naturally leads to imperfections in the way of levying payment for land irrigated; the System under the above described distribution has been:—

1st By measurement of area of surface of land Irrigated, without reference to the amount of water taken, but with reference to the species of crop, and to the means by which the water was obtained, whether by a free flow on the surface, or by the medium of machinery.—

2nd By Annual contracts for machinery, or the payment of a fixed annual price for permission to establish a persian wheel (Ruhut) lever and bucket (Dhinkli) or any of the machines in use for raising water.—

3rd By area of opening of outlet, in contract determined by the parties concerned.—

4th By actual contract for a period of years by which a landholder agrees to pay a fixed price for a water course head with a given area of opening.—

The 1st and 2nd Methods are those most commonly in use on the Canals throughout these Provinces; they are in fact the Methods by which the greatest

portion

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portion of the Irrigation is effected
The imperfections of the 1st are
conclusive; they embrace amongst
other minor evils; those of want
of economy in the expenditure
of water and the introductions
of expensive Establishments, for
the periodical measurement
of land irrigated. They lead
to unnecessary interference on
the part of the Canal Establish-
-ment, with the domestic details
of villages; and from the cir-
-cumstance of the irregular
rotation of crops, they lead to
fictitious returns in so far that
crops for which water rent is due,
have frequently been removed
and the ground has been resown
long before the measuring parties
are able to measure it; The whole
system is bad, as one of unneces-
-sary interference, and uncalled
for meddling in detail; but
bad as it is, it has been much
easier to recognize its imper-
-fections, than to remedy them.
The 2nd Method is a great step
towards improvement; here
the Irrigator is restricted in the
use of the water, by the trouble
and expense of raising it; the
water, therefore, is economized,
and the annual payment
of a fixed sum, relieves both
the givers and receivers from any
further connection

The 3rd Method, is an
improvement on the 1st on the
same principle as that above
described

described; but with a varying surface of head water in the Canal, it is quite impossible as well as utterly hopeless with a mere plank or Shutter to de-=termine any given quantity of discharge. the consequences have been, therefore, that the re-=ceiver has in nine cases out of ten obtained more water than was bargained for, and the re-=sults have been so unsatisfactory even when the utmost has been done to secure the water from misappropriation, that the plan described here, is not of frequent recurrence; the method, however, is so far good, that the transaction is one of contract, without any interference in minor details.—

The 4th Method, is, par excellence, founded on the true system by which water ought to be supplied to the Cultivator, it involves a mere contract transaction between the parties on the signing and sealing of which, the price of the water is secured to the Revenue, and the value of the water is with-=out any interference on the part of the Canal Establishment se-=cured to the Contractor.—

Much as the value of this Contract System has been recog-=nized, it has been found impo-=possible, as a general rule, to carry it into effect; the cause of this impossibility arises in a great measure from the habits

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and disposition of the people there is an uncertainty as to the area of ground that will be irrigated from an opening of a given size; a doubt as to the proportions of water required for crops of different descriptions and the habitual dread that the Cultivator has of being imposed upon by not receiving the supply that he calculated on getting leads him, in all probability, to prefer praying for that which he sees actually measured, to that which in his idea has the appearance of uncertainty —

This System has, however, been carried out to a considerable extent on the Canals west of the Summa, where Contracts have been entered into for periods of 20 years; these Contracts, however, do not unfortunately correspond with the Revenue Assessments, and they were made at a period when the Canal supply was very much less than it has been for the last few years; the consequence has been that although in some cases the Contractors have from a variety of causes been allowed to give up their Contracts, those who have kept them, are benefitting in a very great degree — The position of the outlet on which the Contract was made, remains fixed, whilst the Value of the additional Head pressure, gained by the increase of supply in the Canal, has fallen to the share of the Contractor. —

It

It was the beginning of an improved system, and as such deserves every commendation; and the utmost that can be said against it, is that it has given to the fortunate holders of the Contracts extraordinary benefits, which in all probability they never contemplated, whilst at the same time it has undoubtedly led to the extension of Cultivation and to the breaking up of new ~~ground~~ ground, both of which will ultimately lead to an increase of ~~both~~ Land and Canal Revenue.

Practically speaking, however, the necessity of non-interference with the Heads of these Contract Water Courses, all of which are situated on the Main line; has prevented the extension of the Rajbaha system, and has in some cases interfered with the improvements which have been in progress on the main line of the Canal. I have no doubt that it is from these causes partly, that the System of giving Contracts for long periods has not been continued, and that the termination of those now existing is so anxiously looked forward to, by the Canal Executives. Nobody however, doubts that the principles on which the giving of these Contracts originated were good, and that the same security to non interference which was so desirable in the land measurements,

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was equally so in those for Irri=
gation: in fact, had the Contracts
when made depended on a fixed
discharge, instead of on a fixed
area of opening, the desideratum
which had been so long coveted
would have been obtained, and
we should at that early period
of the history of these Canals
have been furnished with a Modu=
lus, on which the distribution of
the water might have been
adjusted.

It is to this adjustment,
to this determination of an unit
by which water can be equally
distributed, and of the invention
of a machine by which such
units can be discharged in a
given time, that we have to
look to a fair and economical
expenditure of the Canal supply;
whether the Milanese Module
(Magistrale) or any other ma=
=chine is introduced, the results
will be equally satisfactory, if
we can obtain even a moderately
close approximation to the
quantity of water which is
required for the irrigation of
given areas, or which is adapted
to the wants of individual
Estates. To know in fact the
true value of the property that
we hold for distribution, and
the extent to which that property
can be made the most bene=
=ficial to the Community; are
the great desiderata to which
all our views ought to be directed

It

It was with a view to a full acquirement of knowledge on this point, as well as on the legislative Enactments connected with the Irrigation in Lombardy and Piedmont, I should say rather of that of Northern Italy generally, that Captain Baird Smith of the Bengal Engineers, who for many years had devoted his time to the study of Canals for Irrigation in these Provinces, was deputed by the Court of Directors of the East India Company to proceed to Lombardy and Piedmont, and to report upon the Canals of those and the neighboring States.—

The results of Capt. Baird Smiths visit to Italy have been now for some time before the public, in a work which is full of the most detailed information, and which abounds in suggestive remarks, connected with the Methods adopted in the Irrigation and its Management in these Provinces as compared with that on the longer Established Canals in Italy.— The work itself is in fact the text book by which our operations must necessarily be guided, and it will, under its authors auspices, lead to a complete reorganization of our System.—

The known imperfections however of the methods adopted on the Canals in these Provinces for regulating the supply of water as delivered to the Cultiv-

=vators

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=vators, the fact that Captain Baird Smith's deputation to Northern Italy would throw upon this subject all the light that could possibly be expected; and the certainty that the valuable experience he had obtained would lead to his be=coming my Successor; have induced me to adopt the sim=plest possible designs for the heads of Rajbuhas or for the heads of the works from which the water for Irrigation will be supplied to the Country, with the exception of fixing their positions (a matter that is im=mediately connected with the lining out of the Channels, and comes within the province of the ~~Chief~~ Civil Engineer) the heads of all works of this sort have been built in the form of open Arched Channels, of sufficient capacity to admit of the application of any species of apparatus that may hereafter be determined ~~by Captain Baird Smith~~. As the capacity of these Channels is in all cases either 10 or 6 feet in width with a height in proportion, there will be ample room for the purpose I have, it may be stated, adopt=ed a size of Channel, capable of admitting any form of mo=dule or Machine; my aim having been to give full scope for reduction of area of opening, but to avoid the evils of alter=ation and reconstruction of the original work, which a

Channel

Channel built on too confined a scale would have undoubtedly led to.

The above although but a brief outline of the existing arrangements, is sufficient for the purpose of the present Chapter, it will enable the reader to form an opinion on the progress that has been made and on that which the extension of works for irrigation is tending to make in these Provinces; it will, moreover, act as introductory to the views by which I have been guided in my scheme for laying out the irrigation on the Ganges Canal works; and of my desire to confine myself entirely to that object, leaving the [redacted] occupation of determining a Module of Supply, and of providing a Code for the management and protection of the Irrigation to my successor.

The above preliminary remarks introduce me at once to the Rajbuhas as designed for the Ganges Canal works; the relative stations that they hold between the Main Canal and the village water courses having been before explained.

It will be necessary for the purpose of simplifying the description of the Rajbuhas to divide the Canal works into sections, as both the design for the heads, and that for the Channels vary

Irrigation

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FF, 433; V. I.; M. 2; Ch.

Channel built on too confined a scale would have undoubtedly led to.

The above although but a brief outline of the existing arrangements, is sufficient for the purpose of the present Chapter, it will enable the reader to form an opinion on the progress that has been made, and on that which the extension of works for irrigation is tending to make in these Provinces: it will

Capt. A.G. Goodwyn of the Royal Engrs on the Sr. Sup. of the N. Div. of the Ganges Canal works

Assistant for Roorkee

On my assuming charge of the duty in April 1854, Capt. A.G. Goodwyn of the Royal Engrs. & Lieut. C. Irby Esq. Engrs. employed in superintending the discharges with reference to the plan proposed for distributing the water of the Ganges canal, which had been fixed by the Superintending Engineer, Mr. Colvin, and explained in the preceding chapter;

the Discharges for the Ganges Canal as fixed by that officer proposed to be adhered to, and the actual discharges at the Heads of the Rajbuhas were as follows:-

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Rajbuhas as designed for the Ganges Canal works; the relative stations that they hold between the Main Canal and the village water courses having been before explained -

It will be necessary for the purpose of simplifying the description of the Rajbuhas to divide the Canal works into sections, as both the design for the heads, and that for the channels

vary

vary somewhat, according to locality
There are a few leading Rules
however that have been attended
to and may be noticed before
proceeding further. I here allude
to the general design, the modi-
fications of which will be
explained in the sectional detail

1st Rajbaha Heads as a general
rule have been constructed at
all the Bridges, both on the
right and left of the Canal,
excepting in those Districts
where the declivity of slope
is in excess; in that case the
Rajbaha Heads are limited
to the upper levels, and to the
vicinity of the Masonry
Bridges and Locks.—

2nd The Heads are attached to
the Bridges or works near which
they are situated, and in the
immediate vicinity of blocks
of Land, so that they may be
under the most perfect su-
pervision

3rd The width of these Heads
is on the whole of the main
line, and as far down the
Terminal lines as the 30th
Mile equal to 10
feet; below that they are
6 feet in width.—

4th The height of their Sills or
floorings from the bed of the
Canal, is in the Main
Canal and to the 30th Mile
of the Terminal lines equal
to 2½ Inches; from thence they
gradually decrease in height
until

Capt. Goodwyn was
the Lieutenants, and Sub-
the Fort are 7 the Garrison consists of
Europeans & two companies of Native Infantry
Captain Kinloch, Capt. G. had decided in favor
of Captain Kinloch, and directed that
the Engineers should take the requisite
measures to put the Fort in a
state of defence.
Shortly after the arrival of Captain
Kinloch, the Engineers officer who had
charge of the Works, and Captain G.
had a conference, after which Captain G.
informed me that he had decided to
defend the Fort, with the Garrison
at his disposal.
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vary somewhat, according to locality
There are a few leading Rules
however that have been attended
to and may be noticed before
proceeding further. I here allude
to the general design, the modi-
fications of which will be
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falls and Locks.—
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the Bridges or works near which
they are situated, and in the
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Mile equal to 10
feet; below that they are
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4th The height of their sills or
flooring from the bed of the
Canal, ~~are~~ is in the Main
Canal and to the 30th Mile
of the Terminal lines equal
to 2½ Inches; from thence they
gradually decrease in height
until

until they approach the ter-
-minal regions, at which the
sills of the Rajbaha Heads and
the bed of the Canal are on
one level.-

5th All these Rajbaha Heads
are designed as mere open
Channels, with grooves in
front and rear for the appli-
-cation of Shutters or sleeper
planks.- No further design
has been attempted for the regu-
-lation of discharge beyond
that of the grooves for the ap-
-plication of the above mentioned
wood work, and the supply
of planks sufficient for the
purpose of retaining the
water in the opening of the
Canal.-

6th The Rajbaha Channels
are divided into main lines
and Feeders. The first or main
lines run parallel to the
Canal on both its right and
left sides, extending from the
Assoffnuggur Falls, or from
the commencement of the
high land of the Country on
the whole length of the Canal
and its Branches:- these
parallel lines on their
passage downwards are
met by feeders from the
different Rajbaha Heads
in the neighborhood, - as
shewn in the following
Diagram:-

Diagram

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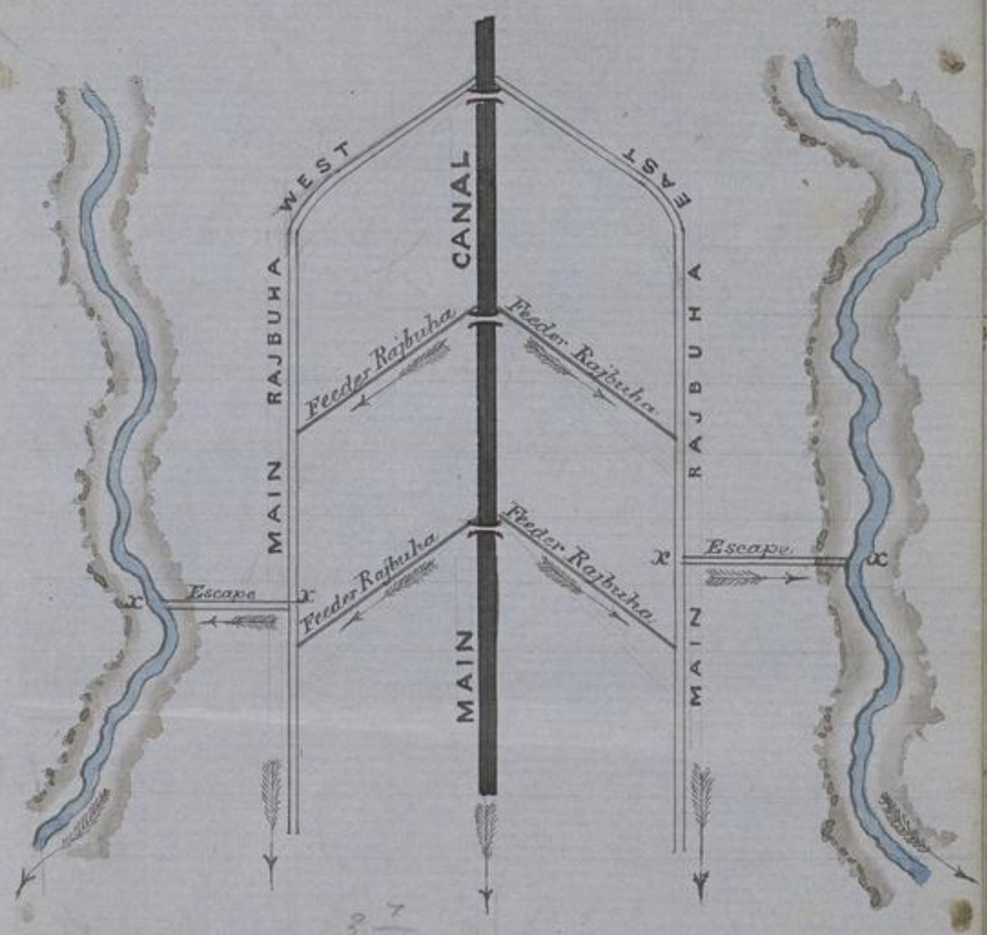

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7th The main lines of Rajbuha as running parallel and approximating to the natural lines of country drainage are connected with them by Escapes vide x x in Diag: which might be multiplied to any reasonable extent, so as to give the most efficient means for riddance from superfluous water; —

8th It is supposed that during floods when the main Canal and its branches are overcharged the opening out of the Rajbuha heads, and the consequent distribution of the surplus ~~disposal of the~~ water over such extended surfaces, as the above system of reticulated Rajbuha Channel ~~Ensures~~ would a tend greatly to the ~~security~~ relief of the works, by a ~~and to the absolution~~ of the Escapes proper, from ~~a great deal~~ dangerous and collected drainage; That obtained by the medium of the Rajbuhas would be divided amongst numerous

numerous Channels, and would finally obtain relief through numerous Rajbaha Escapes; it would in fact enable us to destroy the enemy in detail instead of allowing him to collect in dangerous masses.

9th By the rule above laid down the whole System of Main Canal Branches, Rajbahas and their feeders, become part and parcel of one great Machine; the Rajbaha Heads being the safety valves, and the Rajbaha Escapes being the waste pipes. If pro=perly managed, and if the Sluice Walls attached to the Canal are properly adjusted it is supposed that the scheme above propounded would lead to the maintenance of such an equilibrium in the height of the waters Surface, that no apprehension might be en=tertained for the Main Canal or Reservoir Channels being dangerously overloaded

In the general design for the Ganges Canal, and in the calculations on the supply of water required for Irrigation, the leading 27½ Miles, or that part including the Khadir, and ex=-tending on the high land be=-yond it, as far as the Village of Nusseerpoor, are "considered "as removed from the influence "of Irrigation from their passing "through Khadir land in the "early part of their course, and "deep digging immediately above Nusseerpoor"

"Russeerpoor". This although true to a great extent under the re=
=modelled works, has been some
=what modified by the construction
of the Falls at Assoffnuggur from
the head of which the leading
main lines of Rajbuha are taken
and by the Establishment of
heads for Irrigation for the high
lands of the Khadir. In the former
case, however, the Assoffnuggur
heads have merely led to a re=
=distribution of the supply origin
=ally devoted to the line of Canal
situated between the 27½ and the
110th Mile; and in the latter, the
proximity of the heads for Irri=
=gation to the Ganges River, will
enable us, if necessary, to draw
away an extra quantity of water
for their especial purpose. The
alterations, therefore, although it
may be necessary to allude to
them, do not in any way inter
=fere with the original project
for supply.—

The Country with which the
Rajbuhas are connected may
be classed under three denomina
=tions.—

I. The Ganges Khadir, where
from the natural moisture
arising from its proximity to
the Mountains, the demand
for Irigation is at a minimum

II The lands between Roorkee
and the Terminus of the
main Trunk at Nanoor
on the greater part of which
owing to excessive Slope of
Country

country, the Rajbuha Heads are restricted to the Heads of the Falls

iii. From the Branches where Rajbuha Heads are the usual appendage to every Bridge

i. I have restricted the Heads for supplying Irrigation on this tract to the Kunkul out= =let or escape, and to the Bahad= =oorabad Mills; the former is placed in such a position in proximity to the Branch of the Ganges, that it may be used either for Escape, Irrigation, or for Mills; without any fear of its being injured by either. The latter is connected with the Mill reser= =voir of which work it forms a Component part. Whilst the Kunkul Head will supply water for the villages of Kutanpur, Chandpoor, &c., and to the Eastern portion of the Puttri Lands lying on the banks of the Ganges; that at Bahadoorabad will complete the Irrigation of the Western tracts of the Puttri Forests. From these two heads in fact, any quantity of water may be taken, and at the same time an equivalent is obtainable from the Ganges River, should the irrigation of the Puttri and the neighboring lands call for an extraordinary supply. Although I have re= =stricted the Heads to these two points, there is every facility for providing the most efficient means

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means for irrigation on the whole tract lying from Bahadoorabad to the Puttri River; and the Es-=tablishment of one or two Raj-=bubha Heads on the left Embank-=ment of the navigable Cut w would do everything that could possibly be required,- beyond this and in the vicinity of the great works at Dhunowri, and Roorkee in connection with the Putnoo and the Solani Rivers, Irrigation is hardly required. In the im-=mediate neighborhood of the Putnoo, Spring water is near the surface, and on the Peeran Kulleean ridge the depth of Canal Channel is opposed to its use ~~as a supply~~ for irrigation. At the down stream extremity of the Solani Aqueduct, however, the inlet drains which are con-=nected with the Cattle Ghats, are designed in a way that will render them available for the Irrigation of the gardens and land both at and in the neigh-=borhood of Roorkee: they are in fact in design similar in every respect to the Inlet that has been universally adopted on the Ganges Canal works, viz.: a Masonry Channel opening into the Canal, with its Head in the form of a circular Well or Cylinder, in which the water stands to a height equal to that of the Canal high water mark

II. The Rajbuhas on this Section are as far as the 10th Mile

Plumb

105¼ Mile, or to the Dasna Falls, entirely limited to the heads of the Falls; or to leading positions on the Canal before it changes its level. From the Dasna Falls to the works at Nanoor, or to the 180½ Mile, this limitation ceases, and although in the immediate vicinity of the Falls at Simra and Pilra, it partially exists; Heads for Rajbuhas have been constructed with few exceptions in connection with every bridge

At the Assoffnuggur and Dasna Falls, or at the Head and Tail of a long line of rapid descent in the country which is overcome by masonry works; the Sills or floorings of the Rajbuha Heads, have been laid down on a level even with the Canal bed, or to speak precisely, 3 inches higher, an elevation which has depended on the arangement for the Sluice Shutters: The Escape of water, therefore, at the head of the irrigation at Assoffnuggur, and for the head supply of the main Rajbuhas East and West, will be free and unimpeded; it will be in direct proportion to the depth of water on the main Canal.- A similar remark applies to that at the Dasna Falls, which may be considered as the head, and the command-ing supply of a line of country comparatively flat which lies beyond it.- In both the above cases, however, I have by keeping the floorings of the Heads as nearly as

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as possible on a level with the Canal bed, given the means of supply to the utmost extent that the Canal will admit of

In every other case, both at the Heads situated at the Falls between the extreme points above mentioned, and at those below Dasna, the Sills of the Rajbuhas Heads are placed ~~1 foot~~ above the Canal bed, so as to prevent the Channel from being drained to its uttermost dregs, and to secure a supply to a certain extent ~~equal at least to 2½ Inches in depth~~ to the Canal works below ~~them~~

In making a commencement (May 1833) to the Rajbuha Excavation on this section, the rules which were drawn up for the guidance of the Executive Officers, and which I shall enter in this place, will give a very fair idea of the details of both the lining out and construction of the works. The rules in question were issued on the 29th of November 1832 to Mr Read and to Mr Volk the former having the Executive charge of the works down to the 110th mile, the latter holding that from the 110th or from the Bolundshuhur Branch Head, to the Narora Regulators.—

"1 "The principles on which Rajbuhas are constructed and laid out, need not be explained here, it will be sufficient, to state that the object of such works is to effect

=fect irrigation at the cheapest cost, by laying out lines for Irri=gation on true and correct levels, and by reducing their slopes of bed to a minimum sufficient to keep up a scour, and at the same time to maintain a good head supply for Irrigation.—

2 ᵈ The Method of accounts and of obtaining ground for the purpose of these Rajbuhas, are ~~explained~~ as follows:—

1ˢᵗ The cost of a Rajbuha to be estimated, and on that Estimate assignments to be granted—Accounts to be kept separate under the head of "Tukkavi advances"

2ⁿᵈ The Land which will be occupied by these Rajbuhas, is to be obtained in the usual form, and on the usual scale of remission.—

3ʳᵈ The Amount of remission to be annually debited to the Zumeendars, in the above account of "Tukkavi advances" until the Rajbuhas are accepted by the Zumeendars as lines of Irrigation.

4ᵗʰ On the Rajbuhas being ac=cepted as lines for Irrigation the remission is to cease*, and the

*This will be a question for after consideration; it would be better that the remission should be charged as before to the Dr side of the Rajbuha account, by which arrangement the holder of the land over which the Rajbuha runs, and which is necessarily kept out of Cultivation, would receive his pass and full remission for the land so occupied; whilst the amount of remission would be levied from the Irri=gators generally:— It is evident that the Irrigators in general, and not the individuals whose land is occupied by the works of the Rajbuha, ought to pay the remission: which in fact is a legit=imate portion of the annual expenses of outlay & repairs

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the advances including the outlay for remission formerly made, are to be repaid by the Zumeendars in kists, at periods which may ultimately be fixed, and which would depend on the time when the works north of Roorkee can be dependen on for a regular supply of water.—

5th That water should not be given to the lands of any Village until the Zumeendars have given a written agreement to accede to the above Terms.—

6th The whole of the cost including payment for ground rent which will be periodically remitted to the Collector on his demand will be charged on the Dr Side of an account, which will be opened in a separate book. An abstract of this account, with (after the first account has been rendered) arears brought forward, so that the Director of the works may be kept fully acquainted with the expenditure, is to be submitted Quarterly in the form accompanying.—

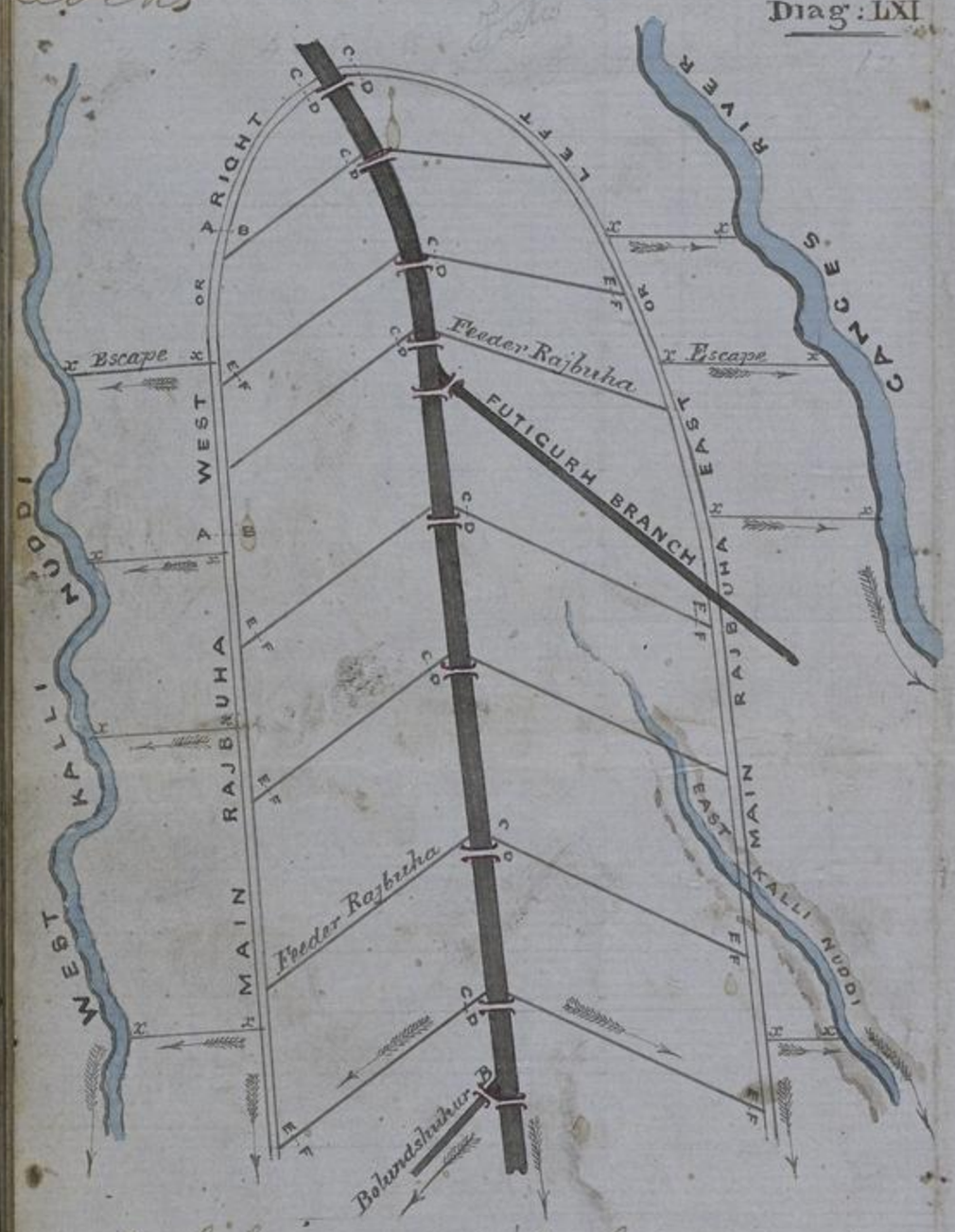
Dr Assofnuggur Main Rajbuha Cr:
(East)

Total Cos Rs		Total Cos Rs	

The

3. "The following Sketch explains in Skeleton the general design of Rajbuhas in Mr Reads Division. the Main Arteries (shewn by double lines) being kept supplied by feeders (shewn by single lines) from the Rajbuhas Heads which are situated above the Falls and Locks

Diag: LXI



"A bridge will be required at the Futtiguhr Branch, combining a passage or Aqueduct for the Rajbuha. The Rajbuha will also cross the valley of the East Kalli Nuddi by an Aqueduct connected with a raised Imbankment; the designs for these works neither of which can be determined on, until the direction of the Rajbuhas is accurately laid down—

4 "The East and West Main Lines or Arteries, must run on the ridge

ridge between the main Canal and the Valley that bounds the Irrigation on the right or left: or in other words on a line from which the water may flow towards the Sides with the greatest facility. Executive Officers will observe that these lines will not be mathematically Sentrical but that their directions will depend upon the profile of the Country. Great care, observation and judgment will be required in determining the course of these main lines, as well as in calculating the slope of bed; as a general rule, I should make the line from the Assoffmuggur Rajbaha Head, as far as the first Masonry descent with a slope equal to that of the Canal, viz 1/4 foot per Mile, so that a good and rapid run might be given to the water on its first admission into the Rajbaha: from the lower level of the first Masonry descent above mentioned, I would make the slope of bed either 9" or 12 Inches per Mile, the superfluous slope being overcome by Masonry de-scents. I would also make all the feeders with a slope of 1/4 foot per Mile, and I would endeavour so to arrange the direction of the feeders that they should enter the Main Rajbaha, by a Masonry descent or overfall, with a drop of from one to three feet.

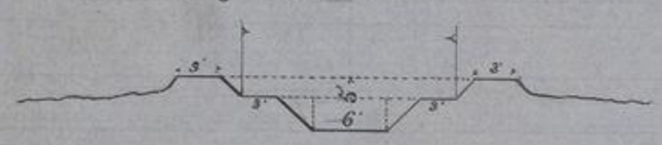
5th Before commencing Excavations Executive Officers will send

their protracted lines of levels to the Directors Office for approval, with their own projects for the slopes of the bed marked upon them.—

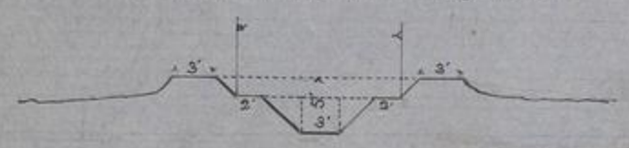
6 "The dimensions of the Main Rajbaha and Feeder Channels will be as follows, those which are given to be considered as minimum ones.—

Diag: LXII.

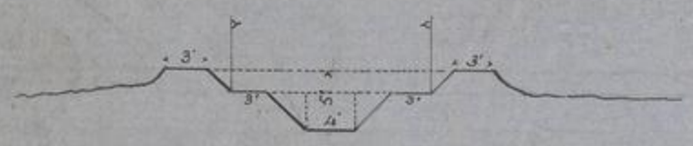
Section on CD, or at the Heads of Rajbuhas and Feeders



Section on EF, or at the tails of Feeders on their entrance into Rajbuha



Section on AB, or on Main Line below 1st Masonry descent..



"Slopes of excavation equal to depths; Slopes of banks 1½ to 1.—

"These lines should be carried out at right angles to the main Canal* for a distance of a furlong at least, and in laying out the levels, and in fixing the pins for excavation I would recommend, furlong distances or even portions of miles, each portion being excavated in one horizontal level, commencing

* In cases where Rajbaha Heads are situated at Bridges, and when the Masonry Channel lies obliquely to the line of Embankment, the Rajbaha Excavation will be carried on in prolongation of the bearing at which the axis of the Masonry Channel is situated.

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commencing from the sill or level of the upper flooring of the Rajbaha head.—

7th The Banks, berms, and Slopes, will be made regularly and neatly as is done on the Main Channel.

8th The Bank on the Sunny or Eastern side will be considered the line of "gusht" (Patrol) or road bank.—

9th The Channel, berms, and Road bank will be kept clear from grass and jungle always.—

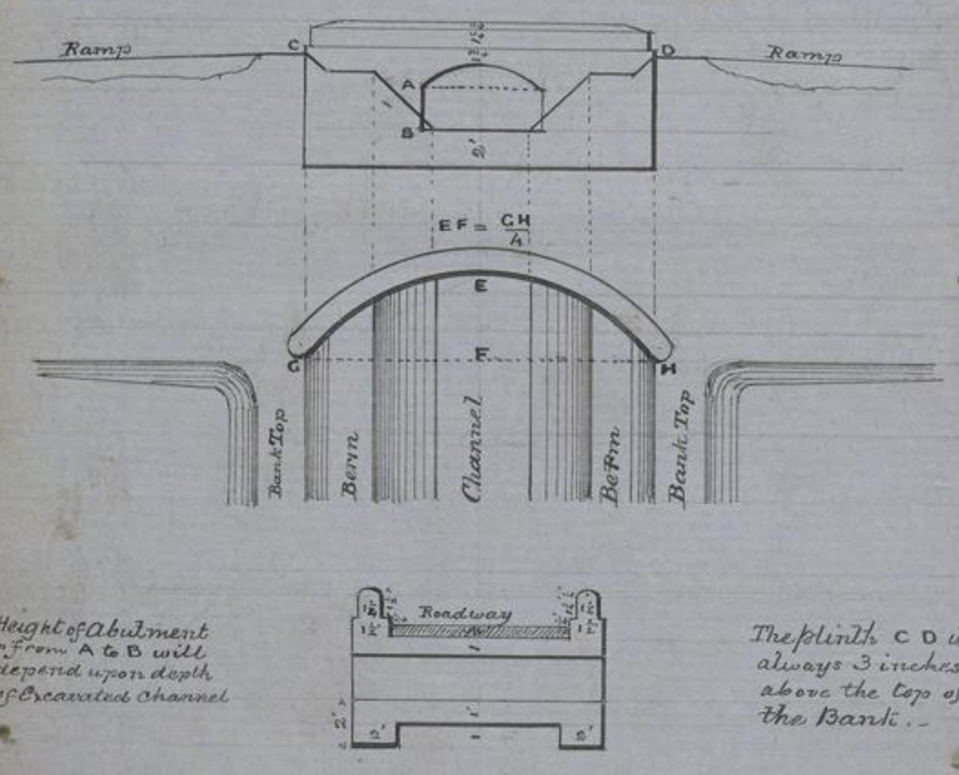
10th The best depth "in soil" for Rajbaha Excavation is considered to be 3 feet, by which depth, surface irrigation, and the repairs of the Channel appear to be most easily managed. Varieties in depths of excavation, however, cannot be avoided, although in laying out the Slopes of bed, and in determining the position of Masonry descents, Executive Officers must be guided by the above approved depths, and by the well understood inconvenience of shallow excavation and the consequent necessity under such circumstances of 'Bank raising'

An inspection by Executive Officers of the Eastern Kumra Canal Rajbahas would shew the advantages and disadvantages of different depths of excavation

No "Kutcha" or earthen slopes Ghats are to be permitted in either the Rajbahas or Feeders—Wherever lines of crossing are required, the cross communication will

will be effected by a Masonry Bridge, the plans and designs of which will be of the simplest description, as shewn in the following Diagram.—

Diag: LXIII.



Height of Abutment of from A to B will depend upon depth of Excavated Channel

The plinth C D is always 3 inches above the top of the Bank.—

12 "The width of Bridge waterway is always to be 2½ Inches greater than that of the Nulla or rectangular Section of the Canal at the point where the bridge is built; i.e. on the Mainline of Rajbaha when the width of Nulla is 4 feet, the width of Bridge waterway will be six feet. The flooring of the waterway must be carefully laid on the true level of the bed. It is better to lay this flooring too low, than too high: the former leads to no great difficulty, but the latter is a positive evil

13 "The width of Roadway of village bridges is to be 12 feet between the Plinths.

Do of Town roads or roads near Towns 15 feet
Do of District Roads 20 "
Do of Anglo Military Roads 25 "

"The

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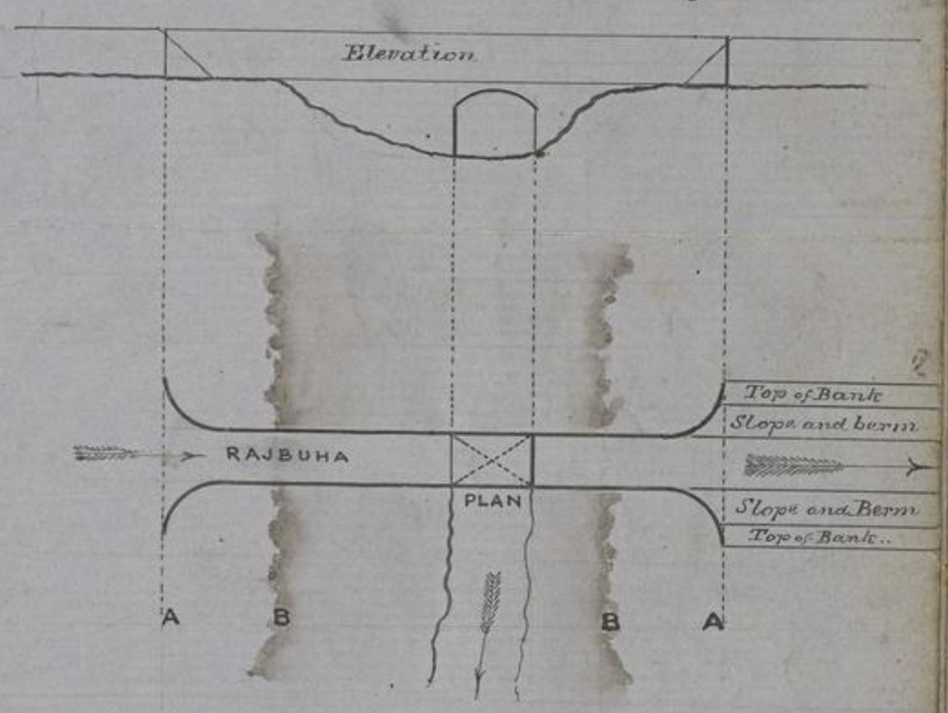
12. "The width of Aqueduct Chan=nels is always to be 12 Inches greater, than the Rules of the Excavation at the point where it is built. -

15. "When a line of Rajbaha or feeder has to cross a hollow or low track of land, great care must be taken in making the wings of the Masonry Channels for the passage of the Canal water sufficiently long, so that they may be well imbedded in the Embank=ments, and that they may rest well in Soil. -

Thus

Diag: LXIV.



"It is not easy to fix the dimensions or distance from A to B: but the Engineer employed on the work must be guided by his own judgment. I may men=tion that in every case where the above rule has not been attended to, disappointment has taken place, in either the water es==caping, at the point of junction between the Earth and Masonry, and in such cases by a failure in the Masonry; or in great after trouble

trouble being given in protecting the entrance and exit in and from the Masonry Channel.-

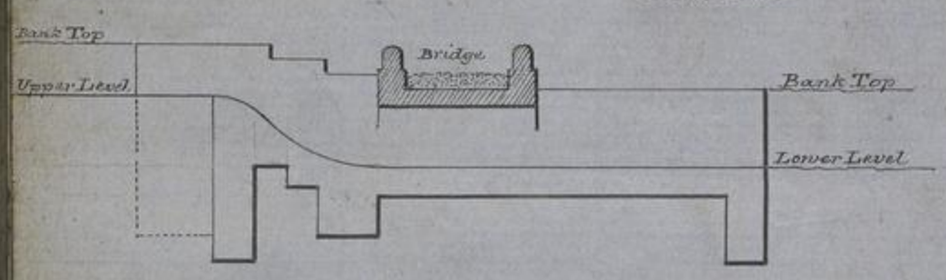
16 " When the line of road crosses the Rajbaha or feeders obliquely the arches of the Bridges may be built Skew fashion.-

17 " The arrangements for delivering Water for Irrigation to the Cultivators by Channels through the Rajbaha Banks will be left for after consideration.-

18 " The descents in Masonry will be of the plainest construction in ogee similar to the design on the main Canal- Plain flank walls with curved terminations, well fitted into the sides both on the up and down stream extremities.-

" Where cross communication takes place at a descent, it is better to keep the road on the lower level by throwing the arch over the lower instead of the upper Revetment wall.-

Diag: LXV

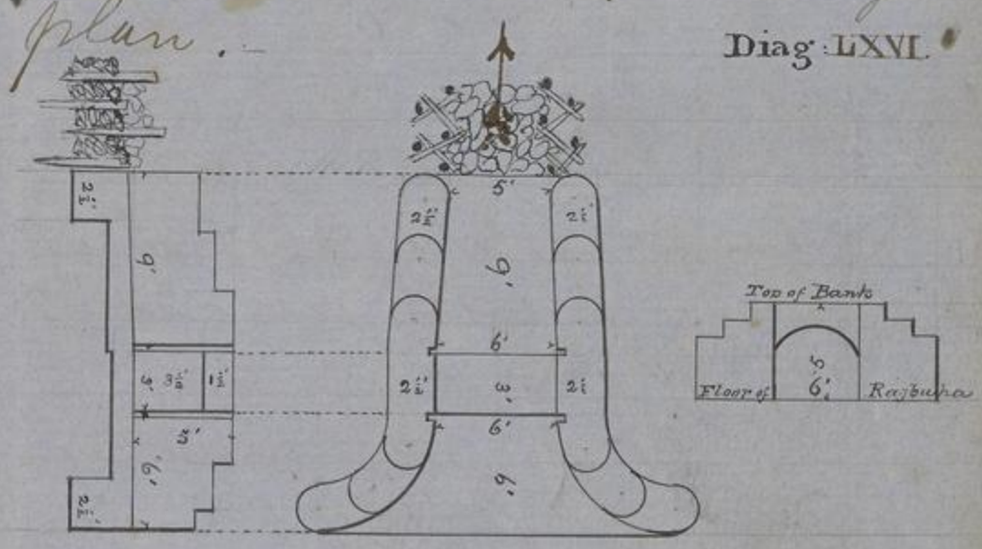


Grooves for planks are on no account to be admitted in the design of these falls, working Plans of which will be provided hereafter.-

19 " Escapes into the side Rivers must be designed at numerous points

points on the main line of Rajbaha, vide x x Diagram LXI; these points should be as near as possible below the junction of a feeder. The width of Escape to be six feet with a weir protected tail on the following plan.—

Diag: LXVI.



20 "In crossing deep hollows where it is necessary to construct an aqueduct for the passage of the Rajbaha; it is always desirable to establish an Escape above, or on the upstream side of the aqueduct. This Escape ought to be built at a point selected for its convenience, and for its offering easy means of delivering the Escape water into the low levels with as little wear and tear as possible.—

21 "The use of the Escapes referred to in para: 20, ought to be reserved for occasions when the protection of the aqueduct is needed; for this reason, that the situation of these works will be generally a dangerous one, from their proximity to the high Embankments.—

"The Escapes described in para 19, are especially designed for relieving the Rajbahas, the

Main

Main Canal, and the country from excess of water during the rainy months.-

22. "The method of crossing the Branches and Escapes connected with the Main Canal by combining an Aqueduct for the passage of the Rajbaha water, with a bridge will be described, and a design furnished, when the Profile of the Rajbahas as connected with the above lines is submitted.-

"The Main line of Rajbaha ought for the sake of economy, to be directed upon the probable site of a Bridge on the Branch or Escape."

The above in describing the detail of Operations required in the making of Rajbahas will point out the Method in which the works are executed. It has been before explained, that the whole of these works are the Private Property of parties unconnected with the Government: that instead of making money advances to the Irrigators for the purpose of digging water courses, the failure of which had in the early history of the Canals been complete, the Government takes the initiative, and has the water courses under the name of "Rajbahas" executed for them: the Government in fact makes the advances in "Rajbahas" instead of in "money", and should the

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the economical and simple designs which are explained in so much detail in the above quoted Memo.=randum, be viewed with an eye to criticism, or should the mi.=nuteness of detail into which I have thought it necessary to enter be considered superfluous; it must be remembered that the circumstances under which the works have been undertaken ~~must be considered~~, and the interests of the Irrigators who ultimately have to pay for them, call for the strictest economy in ~~money~~ expenditure ~~they required~~.

It would be needless, laying aside the impossibility, to enter here into the minor details of the Irrigation, or of the precise direct=ion of the Rajbuhas and their feeders, all of which will depend on the results of Surveys which up to the present time I am now writing (1853/54) have only just been began. The general outline sufficiently explains the object of the undertaking, and the principles upon which they have been founded.

In looking at that portion of the Canal extending from the head of the Bolundshuhur Branch, and in estimating the value of a supply the whole of which is obtained from the Heads of Falls, situated at a con=siderable distance from each other, I may observe that independently of the arangements made at the Aslofnuggur and Dasna Rajbuha Heads by which the supply will be greatly facili=tated, the position of the heads universally

the head of the Irigation at Aslofnuggur to the 110th mile or to —

universally is favourable to obtaining water from the Canal Channel; those on the right being situated immediately above the bridge of boats, which stretches across the main Canal at and below the Navigable Cut head; those on the left being connected with the upper Revetment of the Lock and Waste Channel by the Opening and Shutting of which their supply will be regulated. —

The theoretical supply for each of these Heads is equal (as I have explained elsewhere) to 41¼ cubic feet per second, or to the Irrigation of (218 × 41¼) 8992·5 acres; and it will be delivered under such peculiar advantages of slope of country, that those portions of the Mozuffurnuggur and Meerut districts which come under its influence, are most favourably situated for Irrigation. —

The upper and in fact the greater portion of the Mozuffurnuggur District which will be thus benefitted by the Ganges Canal, consists of a light Soil, frequently accompanied by Bhoor or Sand hills, and in the immediate vicinity of the main line in its passage by Togulpoor, Dimat, Chitowra, &c., Irrigation from wells is scarce, and very extensive tracts of land are occupied entirely by Khureef or rain weather Crops. Canal Irrigation will here create an entire revolution in the Agriculture of the Country, and as has universally

=versally been observed wherever Canals have been carried, a com=plete change in the level of the Spring water; The cause of this alteration in Spring water level, arises, I imagine from the direct ~~connection~~ of the Canal Channel with the wells themselves by the substratu of Sand, or soil of a pervious nature. That we have come in contact with these Sandy Substrata, and, therefore, with those links by which the wells and Canal are connected ~~I have given~~ has been provided sufficient evidence in the increase of Estimates caused by the Sandy beds in which the Canal Channel has been excavated. The strata of Sand Judging from the wells, and from the outcrop as exhibited in the scarped faces of the high bank overhanging the Ganges River, underlie the superficial mould throughout the ~~whole surface~~ part of the of this country: and it is possible that ~~if the above theory is correct~~, the same cause that influences the Spring water in wells, may act in the introduction of Springs on the high bank of the Khadir. The nearest approach of the Canal Channel to this bank is 1¼ miles in many cases, however, Rajbaha lines will run close upon it; we may, therefore, expect leakage although to an extent which will not I imagine be injurious

In laying out the Rajbahas on this tract of country, the most interesting features appear to be the passage of the west

Kalli

Kalli Nuddi for the purpose of irrigating the country lying on the right of the latter River; and the introduction of Irrigation on the Section of land lying between the Choya and the East Kalli Nuddi, especially upon that part of it in the proximity of Hauspur and the Government Stud lands.

In both these cases, a leading line might turn the heads of drainage, and be afterwards maintained in supply by feeders carried across the intersecting River by aqueduct. For instance the head of the Seela Nulla which lies on the west of Roorkee might be turned, and Irrigation be provided for all the land lying between it and the west Kalli Nuddi; in its passage onwards, the Rajbaha would cross the latter River by aqueduct, and in its prolongation down the Country lying on the Right of the west Kalli, would be met by a feeder carried across the Valley near Mozuffurnuggur. This feeder would on its way provide Irrigation to the Country through which it runs, in addition to the supply that it would give to the west Kalli Nuddi Rajbaha. It is doubtful whether for the purposes of Aqueduct the existing Bridges on the west Kalli Nuddi might in any way be applicable in using the space under the roadway of their Cut waters as the supports of a water Channel; their roadways are in all pro-

^ altho even in this case the syphon plan of channel, is an available expedient.

=bability situated on a lower level than that which would be required for the bed of the Rajbuhu Channel ^

Again in the case of the Dauspur Stud lands which lie at the junction of the Choiya with the East Kalli Nudai, as well as for the Irrigation of the land lying between these two Rivers & Rajbuhu from the Bhola feed=er would turn the heads of the Choiya, and might in prolong=ation be not only extended to Dauspur, but it might be continued onwards and across the Choiya at some convenient point on its approach to the East Kalli Nudai - Its tail water might by these means be brought in circulation ~~through tooth~~ through the Rajbuhas below - Feeders from the Rajbuhas which are situated between the Bhola and Dasna falls might by being carried across the valley of the Choiya, maintain the Dauspur line in an ample state of supply

On the whole tract of the Country therefore, lying above the 110th mile, or above the + Bolundshuhur Branch there appears to be the most perfect means for supplying irrigation

From the 110th to the 185th mile, or to the Narroon Regulator facilities for supplying water from the main Canal or + Reservoirs are given at almost every bridge, at every one in fact where such is necessary - At the crest of the high land over

=looking

=looking the flats lying at the heads of the Seyngoor, Rinde and Cesum Rivers, the Rajbuha heads situated on the upper levels of the Pulra and Simna Falls (the general design of which is similar to those at the falls before described) give a command of water sufficient to maintain the main Raj=buha lines ~~to~~ below ~~which lie before~~ them in full supply. I dont in this place allude to the Bolundshuhur and Koel Branches which are specific=ally attached to the Ratras irrigation, under which they will be described hereafter.—

Between the points above described, the main line of Canal runs ~~between~~ with the Eastkalli nuddi on its left, and the Kurvon and the Bolundshuhur and Koel Branch Irrigation on its right. The East Kalli nuddi being at one point within 1/4 Mile of the Canal Channel. The East Kalli nuddi on all this line ~~passes~~ through a wide tract of Khadir land, depressed more or less below the surface of the country upon which the Canal runs, and sufficiently so at all points to give the fullest facilities for enabling the Engineer to pass it by Aqueducts. The works for this purpose would consist of raised Earthen Chan=nels, with Masonry ~~at~~ their points of immediate contact with the River. The Rajbuha works on the Eastern Jumna Canal offer so many

Examples

examples of apparent difficulties of this sort having been overcome without the slightest trouble, and at a comparatively very small expense, that I should not hesitate in treating the East Kali Nuddi and its inauspicious looking Khadir with the utmost indifference. Rajbuhas, therefore, I should say would be carried from the main line of Canal boldly across the valley for the Irrigation of the country on its left bank I would especially select the neighborhood of Mamun where the ~~Contiguity~~ proximity of the Canal and the Khadir is at a minimum, for the site of one of the leading Aqueducts over the valley - The Rajbuha Heads above this point would act as feeders to supply this Aqueduct, the width of its channel might be 10 feet The design for the distribution of the Rajbuha lines on this tract may be best described by the following diagram

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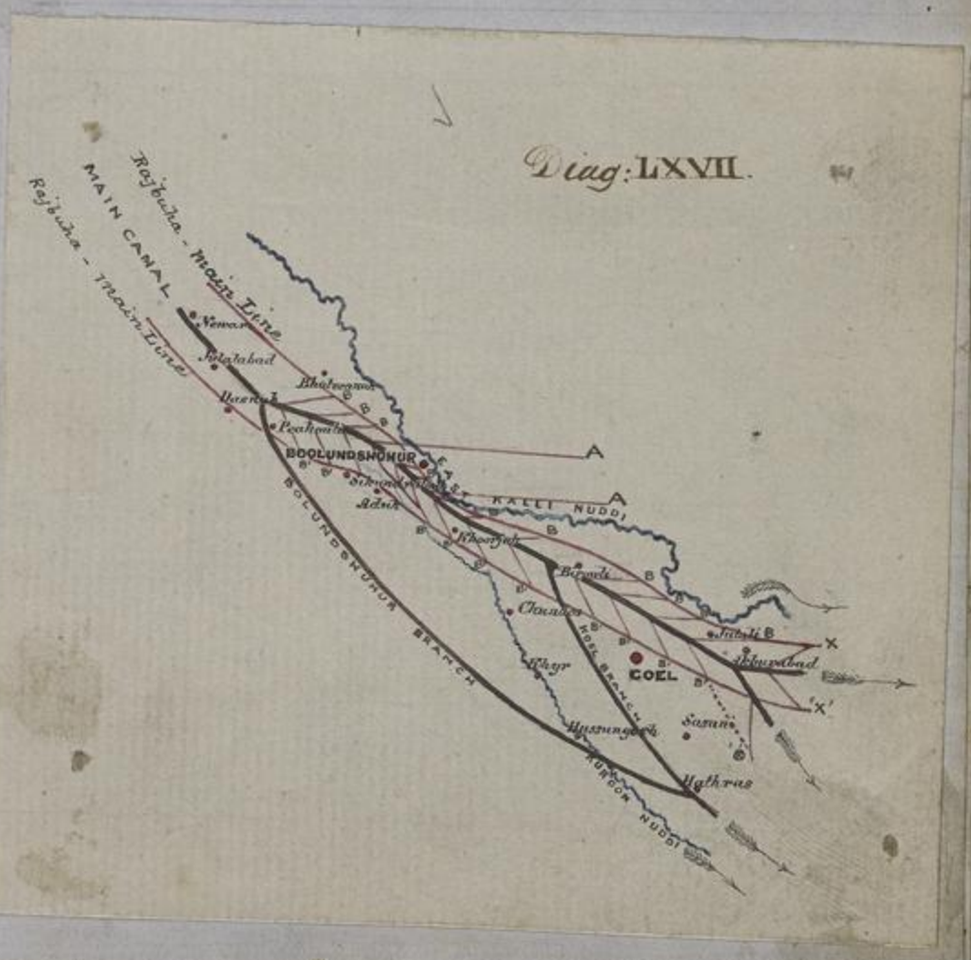

The above Sketch is supp=
=positious altogether, but it
shews that at those points where
the Canal and East Kalli Nuddi
come in the closest proximity,
I would propose aqueduct lines
for passing the River: these
in the above Diagram are marked
AA, and their number might
be extended to any required amount
adapted to the supply of water
that is available: the County it
will be recollected claims a theor=
=etical right of Irrigation on a
belt of five miles from the Canal
boundaries: a consideration of
this circumstance will lead
to the calculation of how much
water ought to cross the East
Kalli Nuddi so as to irrigate
the lands which come within
this belt; and consequently what
extent of Aqueduct is sufficient
for the purpose: The feeders
are shewn by the line BB. The
consecutive line marked BBB
is in prolongation of the main
Rajbaha on the left which I have
before describes as commencing
at the Head of the Assoffnuggur
falls. The above merely ~~denotes~~ presents
a general ~~view~~ view of the lining out
of the Rajbahas on the left of
the Canal, but it may ~~perhaps~~
be worked out into a well combined
and comprehensive series of
Channels the waters of which
are in free circulation.-

On the right of the Canal
and keeping in mind that the
Bolundshuhur and Koel Branches
act as Irrigating lines for the
County

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country lying parallel to the Kurroon, and that agreeably to the project the Theoretical area to be irrigated by the mainline is limited to a belt 5 miles in + width; the line B'B'B' which is a continuation of the Main Rajbaha west from Assoffnuggur after + crossing the Bolundshuhur branch either by an under Tunnel, or by an Aqueduct (which might be built in connection with the Khounah Bridge, or with that which is situated about three miles from the head of the branch) would proceed onwards keeping within the legitimate five Miles, and in a direction parallel to the Main Canal. In the same way that the Bolundshuhur Branch was passed, that of Koel would be passed also, and this great western line of Rajbaha would ultimately either cross the Etawah Terminal line and maintain its prolongation downwards as shewn in the diagram at 'X' or it would fall into the leading Rajbaha attached to the Etawah Terminal line, with which it would form a junction as represented in the Diagram at 'O'. To this main line the Rajbahas at the different Bridges would act as feeders, and the whole of the irrigating lines on this tract of the Canal would be placed in one great connected series, through which the water would flow, with an uninterrupted circulation

From both the main lines which I have described, and represented

represented in the diagram as
BBB on the left, and B'B'B' on the
right of the Canal. Escapes (the
former into the Eastkalli Nuddi
and the latter into the Kuroon)
ought to be established at every
available point. These Escapes
might with advantage be situated
AA at every six miles on the course
of the Main Rajbuhas, and
at this distance perhaps could
the not well be exceeded.

The above gives a general
idea of my views of the distribu-
tion of the Rajbuhas ~~lines~~ on
the Main Canal; we now come
to that on the ~~Branches~~ Terminal lines, which
brings us to the third section
of this paper, in which the
irrigation is derived from Rajbuha
heads at the different bridges
unaided by the intervention of
masonry descents, or of rapid
slopes in the surface of the
country.

III. In the former section
we obtained a great command
over the country by the extraordinary
slopes which it naturally possesses;
this enabled us to restrict the
Rajbuha heads to those points
which were best adapted for giving
command, whilst at the same
time, it gave an impetus to the
circulation, by enabling us to
maintain a head and constant
supply under very peculiar ad-
vantages.

In the Cawnpoor and
Etawah Irrigation, these advantages
are wanting, but we nevertheless
from continuing the Rajbuhas
in an unbroken line from the
Pulra and Simra falls down-
wards

W. Allen

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-wards, derive the full benefit of the command which their ele-=vated position enables them to give.

The ~~Cawnpoor or Branch~~ Raj-=-bahu Heads on the Cawnpoor Terminal are situated at every Bridge, or at a distance of about 3 Miles apart, their dimen-=sions on the first ~~thirty~~ Miles of its course are similar to those of the Main ~~Canal~~ line, that is to say, their width of Channel is 10 feet, and the height of their floorings above the Canal bed is 2½ Inches ~~- / - as the thickness of side, and 4 inches beyond its~~ -

From the 30th to the 90th Mile the width of Channel is reduced to 6 feet, and the Sill or flooring is 16 Inches above the Canal bed

From the 90th to the 150th Mile the width of Channel is 6 feet and the Sile is 8 Inches above the Canal bed

From the 150th Mile to the Termi-=nus, the Channel is 6 feet wide, and the ~~flooring~~ sill and Canal bed are on one level with the exception of the head of the Pandoo and Ganges irigation to which I shall advert hereafter, the above dimensions hold good throughout the whole course of the Terminal line.

The slope of the Country from Nunoon to the immediate neighborhood of Cawnpoor varies from 15 to 12 inches per Mile, the greater portion being on the Minimum slope: to gain therefore the requisite advantages

from

from Rajbuha Irrigation it will be necesary to reduce the slopes of the Rajbuha Channels to a minimum, which I should fix at Six inches per mile. This in the first Seventy miles of the Branch, would on each mile, give the Rajbuha Channel a command over that of the Reser-voir from which it was supplied of nine inches. - Supposing, There-fore, that the average level of the Canal or reservoir bed was seven feet below the Surface of the Country, the Rajbuha Channel must lie 9⅓ Miles in length be-fore its bed would strike out upon the Surface of the Country. - From the 70th Mile downwards, where the Surface Slope being only 12 inches per Mile, we could only give Six inches of command on each Mile in length of the Rajbuha; fourteen (14) Miles in length would be necesary to obtain the result above described. - With a depth of water in the Rajbuha equal to three feet, which we may fairly take as an average - the above length will be re-duced in the first case to 5⅓ and in the latter to 8 Miles; which we may consider as the points at which Tor or Surface irrigation would be available. - It will be very evident therefore, that if a proper use is made of the Main lines of Rajbuha which come from the higher levels of the upper country, and if these Main lines are kept well

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* At the Kylumpow Bridge known the full of two feet will give an increased command to the Rajbuha lying above it: in this case the distance at which Tor water will be delivered becomes reduced from 5⅓ to 2⅔ miles. Advantages of an equally favorable nature will exist at the 91st Mile from whence Tor water will be delivered at a distance of 5⅓ instead of 8 miles.

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vell supplied from the Feeders which have been so liberally scattered over the whole length of the Canal. Irrigation will be obtained with facility on the whole surface of the land which comes under their influ=ence.—

Commencing therefore with the left of the Cauvery Terminal ~~line~~, in explanation of the general views that I entertain of the distribution of the Channels. The prolongation of BBB and from its termination X in the above Diagram, I would carry the main ~~line~~ or Eastern Asoff nuggur Raja Cauvery (as it may be still called) straight for=ward, keeping it altogether to the left, and free from the heads of the Rind and the Cesum Rivers. The former I have before explained lie ~~to~~ the North of Nanoor and Akrabad; the latter are situated in the neigh=borhood of Sikunda Rao.— This main line would proceed onwards keeping to the most approved or Summit levels of the Strip of land lying between the Cesum and the East Kalli Nuddi. I apprehend that the course would be in approxi=-mation to the latter; ~~and~~ that it would pass to the North of the Towns of Cyta, Koonaoli Bhongaon, Brown, Chubramow and onwards, keeping to the South of the ruins of Kunoge, It would terminate in the low ground of either the Ganges, or of the Cesum in its proximity to it.—

D

I should treat the Eesun in the same way as I did the East Kalli Nuddi as described in Section II, and as figured in Diagram LXVII. Feeders from the Main ~~line~~ of Rajbuha would be carried boldly across the valley, under precisely the same rules as those laid down for the irrigation above the Nanoon Regulators, restricting the points of Aqueduct to those where the line of Canal and the valley of the River, are in the closest contiguity, and retaining the Rajbuhas at the intermediate points as feeders for the Aqueduct lines. —

The Rajbuha from the Ootha Bridge, or that which is situated at the 130th Mile, would probably be the last in connection with the Main Rajbuha, or that running between the East Kalli Nuddi and the Eesun. The Ootha Feeder would in all probability cross the Eesun by Aqueduct, and act as the last of a series in which the East Assoffnuggur Rajbuha is the prominent feature. —

Below the Ootha Bridge the Rajbuha heads, would provide Irrigation for the tract between the Noon and the Eesun, those situated at the Munowa and Kukwan Bridges acting as the heads of supply for a Main Channel that would turn the low ground constituting the heads of the Noon and in which that River takes its rise; those lying

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lying below Kukrowlee, acting on the usual plan as feeders, by + crossing the Noon by Aqueduct

A general Sketch of the Irrigation on this part of the Cawnpoor Terminal Line is shewn in the following Diagram

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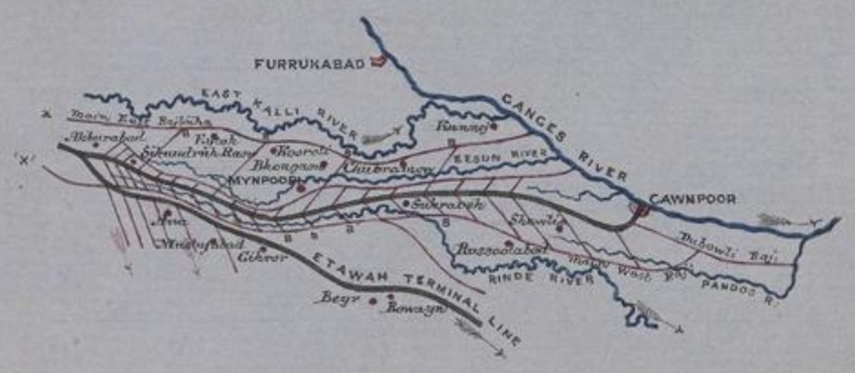
Diag: LXVIII.



On the right of the Cawnpoor Terminal ~~line~~, the Irrigation and the detail of the Rajbuhas are so far the first 65 Miles somewhat more complicated: they are entirely regulated by ~~the Etawah Terminal line~~, which is, as I have elsewhere described in close connection with the Ratrass Irrigation, to which the first 65 Miles of its course are especially devoted.

The Capacity of the Channel of the Etawah Terminal Line has been designed with reference to the Irrigation tending to the Dumna Side of the Doab; to which immediately after its departure from the head at Nanoon it will be expected to throw off large supplies. The greater part of the land lying between the Cawnpoor and Etawah Terminals ~~Lines~~ from their Separation to a point 65 Miles below, will be irrigated entirely from the former

former. The width of country that separates these two Lines does not exceed in average 5 1/2 miles and it contains on its whole length the Rinde River. This River will have to be crossed on the same plan as proposed for the East Kulli Nuddee and the Elsun and should the West Assoffnuggur Rajbuha be prolonged and carried over the Canwapoor Terminal ~~line~~ instead of being dropped into one of its Raybahas, this main line would continue on the right of the Rinde, would sweep through the Sections of land formed by the Ahnaee and Phoora Rivers; would cross these two rivers on their approach in one Channel to the Rinde, and would ultimately proceed onwards as the main line of Rajbuha towards the Eastern portion of the Shatumpoor ~~District~~ Purgunna

It will be understood however, that on the first 65 Miles the Canwapoor Terminal ~~line~~ will supply irrigation for all the tract lying between the two Terminal lines: and that the Rajbuha ~~Heads~~ at, on ~~the~~ its right bank will act as feeders to the great Western Assoffnuggur line which will run on the Right of the Rinde.—

In advance of the 65th Mile the Canwapoor Terminal ~~line~~ continues its course in close approximation to the Rinde, coming nearly in con-=tact with it at the 83rd mile at

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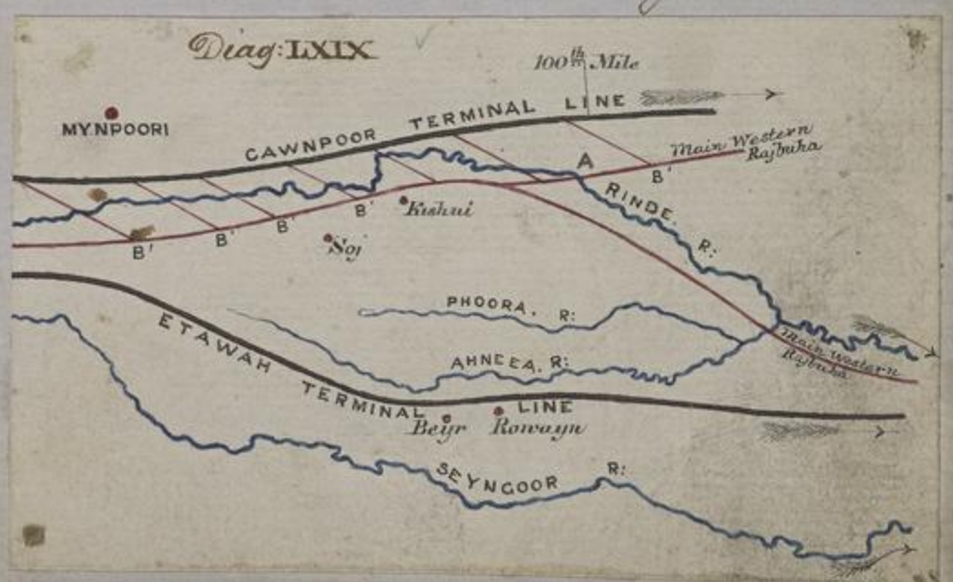
at a point opposite the Town of Kishnii, and continues even as far as the 100th Mile in such close contiguity that the Rajbuhas on the right will naturally cross the Rinde and act as feeders to the great line of Raj=buha which I have above described as sweeping through the County near the Ahneea River.

From the starting point at Nanoor, therefore, as far down its course as the 100th mile, the Rajbuha heads on the right of the Cawnpoor Terminal line will act as feeders to the Main Rajbuha which runs on the opposite side of the Rinde; the detail of Aque-duct arangements being regulated on the principles before suggested

It is desirable for the purpose of retaining the command of water, that the great Western Rajbuha holds at this point, to carry it forward and take it across the Rinde by an aqueduct as shewn in the following diagram at A.. A branch line of equal capacity of Channel however would be continued onwards on the right of and in parallelism to the Rinde, leaving the



Town of Ayewa on the right, and (as described before) crossing the Phoora and Ahneea immediately above their junction with the Rinde. This Branch is the main line for the ultimate irrigation of the Eastern portion of the Ghatumpoor Talooka.

From the Aqueduct at A the Main ~~Line of~~ Rajbuha would be carried round the heads of the Pandoo and keeping on the right of that River it would pass the Town of Shewli? From thence leaving Suchindi on its right, it would cross the Pandoo river by Aqueduct and would ultimately form a junction with the Daboowli Rajbuha; a main line which passing through the County between the Pandoo and Ranges terminates the Cawnpoor irrigation ~~on the Cawnpoor Terassed line~~

The direction with reference to the Towns of Shewli and Suchindi, will require to be fixed by careful and accurate survey; both my own and Mr Dousworth's Maps of the country lying on the right of the Pandoo, will afford good ground work for determining the best ~~line~~ direction for the Rajbuhas: the Country, however, is much cut up by drainage the whole ~~tending~~ tending towards the Rinde, ~~which will require judicious drainage~~.

The line, will, I imagine, cross the Pandoo in the vicinity of the Village of Newri, or not very

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very far from it. The Pandoo is a River that carries a good deal of water during floods, and it would be advisable to select a point for the Aqueduct crossing where the Section is capacious and ~~to render the Aqueduct~~ in designing the building to make it as free from obstructions as possible For this purpose (as well, I may say, as for the same purpose in all cases connected with these ~~rivers~~ Heads) I would use a Steel Iron Channel resting on masonry piers, in preference to Arches which with their Spandrils, occupy so much Space, and offer so much obstruction to the Water way. —

The detail of feeders from the Caumpoor Terminal ~~line~~ for maintaining the supply in a State of efficiency, would be similar to that before described; the Pandoo River would be crossed at convenient points by Aqueducts, and the Channels from the intermediate Rajbuha Heads would act as feeders to the Aqueduct lines

The Heads of the Rajbuhas on the Right of the Caumpoor Terminal ~~line, terminate~~ end at the Dubowli Regulator; here there is a bridge with a drop gate, fixed just below a Rajbuha head — This head acts as the supply for a main line extending down the Section of land enclosed between the Pandoo and the Ganges up to their junction. The Water way is 10 feet with its Sill on a level with the bed of the Canal. The disposition of the

the works at this point is
planned with reference to main-
-taining a constant supply for
Navigation to the heads of the
Cawnpoor Lockage, and at the
same time to afford provision
for all the Spare water to pass
off to the irrigation of the lands
on the above mentioned tracts
The closing of the Gate or Shutter
in cases of drought, and in
Emergencies when water is not
required at the works in Cawnpoor,
admits of the whole of the tail
water being passed off for irri-
-gation on the Duboulee Rajbuha.
This line ~~after leaving its head at the~~ after leaving the Duboulee Regulator would
be carried on the Summit levels
of the Country lying between
the Joandoo and the Ganges;
it would in its course be joined
by the Great Western Assoffnuggur
~~Rajbuha~~ which has been above des-
-cribed, and its tail water,
would ultimately be conducted
into the Pandoo, on the Boundary
of the Cawnpoor and Futtipoor
Districts. -

I may observe that with
reference to the Sanatory laws
laid down for the prevention
of Irrigation in the vicinity
of Towns, the Rajbuha Heads
on the left of the Cawnpoor
Terminal ~~line~~ end ~~in~~ at
the Muswanpoor Bridge, or at
a point situated 3 Miles from
the head of the Cawnpoor works
at the village of Duboulee

From the above description
it will be seen that the main
Rajbuhas on the Right and
left which leave the Canal at
the

the head of the Assoffnuggur
falls, continue in uninterupted
lines the whole way down the
Country maintaining their
course parallel to the Main
Canals or Reservoirs of supply
On the left; to the separation of
the main trunk at Nanoor,
at which point the line takes
a departure to the left, keeping
to the vicinity of the Eastkalli
Nuddi; and terminating in
the Ravines and low land con-
=nected with the Ganges and
Jesur; On the Right, maintain-
=ing an equally parallel course
on a much greater extent even
to the neighborhood of Cawnpoor
at which point it forms a junction
with the Duboroli Rajbuha, and
passes off in connection with
that line into the Pandoo.

The detail of Rajbaha
heads, their position relatively
to Bridges, their dimensions &
and the general arrangements
connected with discharge, are
on the Etawah precisely the
same as on the Cawnpoor
Terminal line.

I have in the former Chap-
=ter, as well as in that under
the head of the Bolundshuhur
and Koel Branches, drawn at-
=tention to some of the leading
points connected with the
distribution of the water from
the Etawah Terminal ~~line~~.
and in the detail of the works
I have in a general way
pointed out the method
that could be adopted for
Main

maintaining a sufficient supply for Lands lying at a distance from the Main Canal it will be sufficient therefore in this place, whilst recapitulating the different details, to bring the whole under review as one comprehensive ~~Series~~ Scheme of Irrigation

From what was said before ~~in the last Chapter~~ it will be understood that on the leading 65 Miles of the course of the Etawah Terminal ~~line~~, the supply for Irrigation will be almost entirely ~~taken away~~ drawn from the Rajbuha heads of its Right bank; this supply which is intended to be free and continuous is in fact the source upon which the Katras line of Irrigation will depend for its existence: On the Principles above described, the Seyngoor will be crossed by Aqueducts, and these Aqueduct lines (which I propose to make 100 feet in width) will be kept in supply by the intermediate ~~lines of~~ Rajbuhas which will meet the Aqueduct line on the Canal side of the Seyngoor Valley. I have supposed that four Aqueducts with a waterway of 40 feet in width in the Aggregate would be sufficient for the Katras irrigation on the first 65 Miles of the Course of the Etawah Terminus ~~line~~ — The position of the Four Aqueducts with their feeders may be shewn in a diagram — the four Main lines being designated by the leading Towns

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Towns or places upon which or from which they are directed

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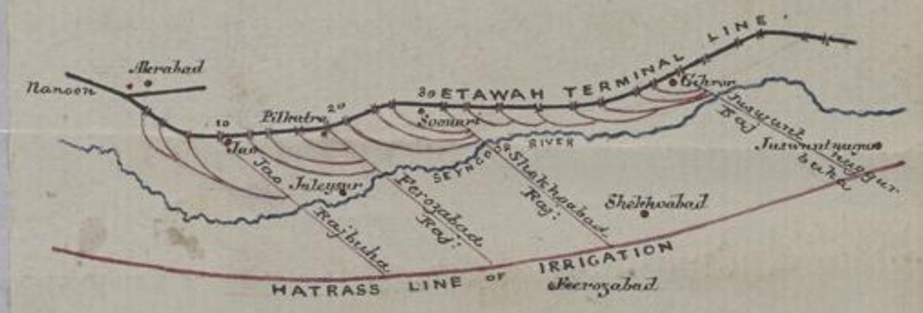
Diag: LXX.


Allerabad
Nanoon
Pilhaitre
Jaa
Juleysur
Rajbuha
Ferozabad Raj:
Shekhupabad Raj:
Shekhwabad
Etawah
Jumna
Jumna
Jumna
Seyngoor
Jumna
Jumna
Jumna

is on the first 65 miles of its course supplied almost entirely from the Caumpoor Terminal ~~line~~ it will be connected with that of the Etawah, by numerous feeders from the Rajbuha Heads lying on the left of that line, but the supply to be obtained from this source is looked upon as one of emergency rather than one of necessity. —

At the 65½ Mile, the Assoff-=nuggur Rajbuha which it will be understood is still the main line for Irigation instead of pro-=ceeding parallel with the Etawah Terminal ~~Line~~ retains its paral-=lism with the Runde, reicing the lands intercepted by the Phoora and Ahneea Rivers. As has been before explained this Western & Assoffnuggur Rajbuha crosses the Runde by an Aqueduct near the Town of Ayrwa, having previously thrown off a branch which continues its parallelism to the Runde, regaining its position relative to the Etawah Terminal ~~line~~ by crossing the above two rivers at a point below their junction. —

To the above ~~line of~~ Rajbuha, the Etawah Branch will from the Ghror to the Gungsi Bridges, provide a full supply from each of the intermediate Rajbuha Heads. A further supply will be delivered by Aqueduct from the heads between the Gungsi and the Uchuldi Bridges across the Ahneea, to the Strip of land lying between that River and the Phoora. The Main Rajbuha

~~line~~

~~line~~ will be kept well supplied with water from the Cauvery Terminal line (as described in a former paragraph) by Aqueduct lines carried across the Rinde in the neighborhood of Kishni, & Tukravia, & Co. —

Confining my description to the Irrigation lying on the left of the Otawah Terminal ~~line~~ the main ~~line of~~ Rajbuha after passing the Ahyeea River, proceeds onwards between ~~the Terminal~~ that line and the Rinde, receiving on its course a supply from the different Rajbuha Heads, until it has passed the Sithnuna Escape; at this point instead of proceeding onwards parallel to the Canal, it pursues the course of the Rinde in the same way that it did on the former occasion keeping on the summit level of the tract of land lying between the Noon and the Rinde. From the different Rajbuha heads situated above the Town of Akbarpoor this main line of Rajbuha and its different branches will receive ~~their supplies~~ ~~the supply~~; ~~It~~ This main line will provide irrigation for all the Eastern portion of the Shahjehanpoor Pergunna, and it will be aided in this by ~~heads of~~ cuts for Irrigation taken from the different Rajbuha Heads lying between the Akbarpoor and the Canal Terminus. —

By the above arrangement the Assoffpuggur West Rajbuha or rather that branch from it which commences from the town of

of Ayiva, will terminate after having run continuously for a distance of 330 Miles in the Ravines of either the Rinde or the Simma in the neighborhood of Dar.-

Looking to the right of the Etawah Terminal ~~Line~~, it has been shewn that the first 65 Miles of its irrigation will almost be entirely devoted to the Ratnas line of Irrigation, and that even as far as the 100½ Mile, or up to the Mulhosi Escape, the above line will be supplied by feeders taken from the Terminal ~~Line~~ by Aqueduct across the Seyngoor.- This System however which leads to the necessity of such a large quantity of water being taken for the Irrigation of the Country lying on the right bank of the Seyngoor, makes provision also for the lands which lie intermediate, all of which have the means of irrigation provided by the main Aqueduct line as well as by its feeders. To the extent, therefore, of the supply of water, the whole tract of country lying on the right of the Etawah Terminal ~~Line~~ from the 1st to the 100th Mile of its course will be irrigated.-

In advance of the 100th Mile, keeping in view the advantages of securing a thorough circulation of fluid, and the consequent necessity of maintaining a main Rajbaha ~~Line~~, or as we may term it a Catch channel ~~Drain~~ for the Spare water of the different feeders; I would adopt the last,

or

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or the Oorya Aqueduct line, as the source of a connected series of Rajbuhas which should extend from that point to the Terminus ~~of the Terminal Line~~ at the Jumna.

I imagine that this last line will leave the Etawah Terminus ~~Line~~ at the Mulhosi Bridge, and that it will join the Ratnas line of Irrigation near the Town of Oorya, having previously to its reaching the Aqueduct by which it will cross the Seyngoor, provided the means of Irrigation to the land in the neighborhood of the Town of Pukhroond. The total length of this (as it may be called the terminating (or Oorya) Aqueduct will be about 27 Miles. in its course it will receive supplies from the different Rajbuha feeders lying between it and the Aqueduct line that joined the Ratnas branch at the Town of Shukrao. The capacity of these Aqueduct ~~cha~~channels ought to be atleast 10 feet in width from the junction of the feeders, and I would not in any case make the Masonry or Iron ~~Channels~~ Passages over the Seyngoor River, less in width than 10 feet.

From this Oorya Rajbuha a main ~~Line~~ Cut would be led off, at a point about 3 Miles from its departure from the Terminal ~~Line~~; it should run parallel to the Canal at a similar distance, receiving in its passage a supply from each of the Rajbuha heads of the diffe-
-rent

=ent Bridges - This main ~~out~~ ~~trunk~~ would probably rejoin the Terminal ~~line~~ at a point below the Town of Ukbunpoor, or it might terminate in the same way as the main Rajbuha on the left, by falling into the Ravine of the Seyng oor in the neighbor-=hood of the village of Sinsen or in those stile farther on, near the Town of Moosa nuggur. -

The lining out of Rajbuhas on the plan that I have represented, necessitates the crossing by aqueduct of every tributary, to which the main ~~line of~~ Rajbuhas run ~~s~~ at right angles, but this crossing by aqueduct is by no means a very expensive or a very difficult operation, and its advantages are so great in enabling us to provide a main line well supplied by feeders in a position capable of pouring water into every corner of the land, that I dont object even to a moderate excess of outlay on aqueducts, if the advantages above described are well secured. -

The Rajbuha Irrigation from the Bolundshuhur and Koel Branches will be conducted on the same principles as those above described, viz^t by parallel lines of main Rajbuhas supplied by feeders from the different heads; these however will cease in the first case on the Right bank of the Kunoon, and before the branch reaches that River; and in the latter at the junction of the two Branches. - In advance of this

junction

out

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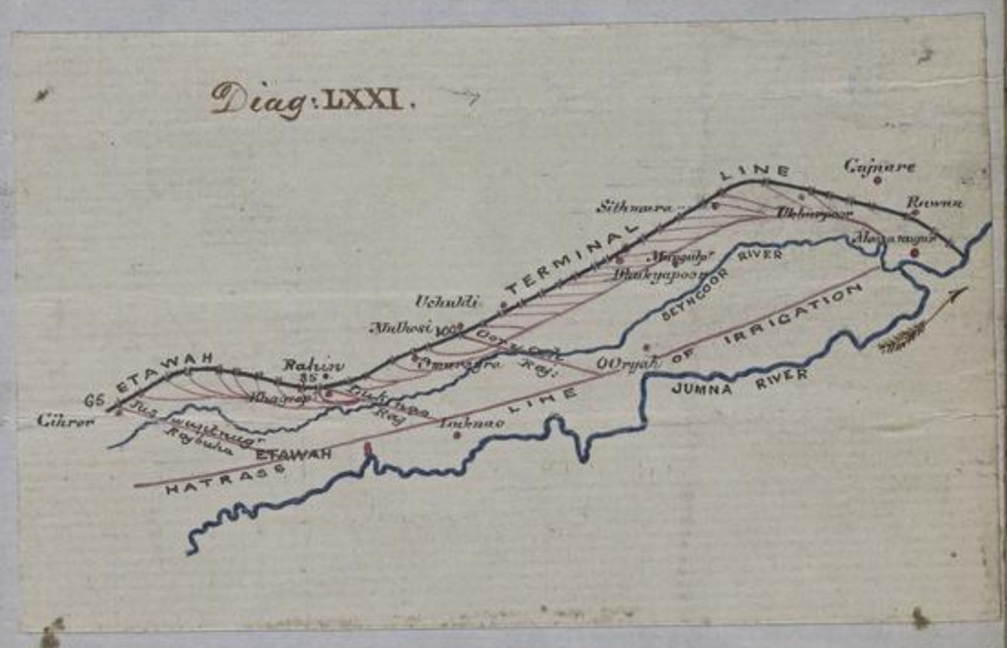
junction the Hatras line will deliver its water for irrigation immediately from the Main Channel, which is supplied, as above described, by feeders from the Etawah Terminal ~~line~~. The description, however, will be more distinct by the following Diag: which represents an outline of the system of proposed Irrigation from the Dussowntonuggur Raj=buha at the 65th Mile to the extreme End at Ukburpoor and Moosanuggur —



The Futtigurh Branch which leaves the Main Canal at the 50th Mile of its course, and runs on the watershed or Summit level of the Section of the Country bordered by the East Kalli Nuddi and the Ganges, will embrace an equally com=prehensive System of Irrigation, carried out on the same Plan as has been described before.— This Branch is proposed to terminate at the 160th Mile of its course as an irrigating medium; the Channel in prolongation being specifically designed for boats, rafts &c., and for the pur=pose

=pose of connecting Suttiguch with the main ~~Trunk~~ Branch by water Carriage.—

From the departure of this Branch, therefore, from the main Canal at Paoli, or rather I should say from the head of the Falls which are situated below ~~Nearest to~~ it; main lines of Rajbuhas, would be carried on the Right and Left Parallel to the course of the Branch, receiving their supply from each Rajbuha head in succession. The main lines would terminate in the Navigable Channel, at some convenient point below the 150th Mile. The System of ~~main lines~~ Rajbuhas and feeders, with a complete circulation of the Current would be maintained on the Suttiguch Branch as it has been proposed to be done on the whole of the Canal lines

Some apology is necessary for the length to which this Chapter on Rajbuhas has been extended; it has not arisen from any intention of laying down definite rules; nor presumption that any experience I may possess may warrant even an attempt at fixing the position of lines, or determining the distribution of water.— These must necessarily depend not only on the result of carefully acquired field observations, but on the wants of the country, and on the natural qualifications of land for receiving irrigation.— My reasons for entering into so much detail is, the recognised

fact

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fact, that a plan once laid down offers a base upon which something may be constructed; if the plan shews nothing but the ignorance of the designer, it has the merit of pointing out the evils to be guarded against; if generally or only moderately applicable to the purpose, it relieves others from preliminary and rudimen=ary trouble, and enables the mind to be employed on improv=ing that of which the original is the mere ground work.—

In the present case, the interference of Rivers, and the peculiarly narrow sections of country through which the Main Canals take their course render the distribution of the Rajbuhas ~~Lines~~, a somewhat com=plicated Question; it is one that has given me much thought, and the conclusions at which I have arrived, are the results of mature and deliberate consider=ation.— The general principles are derived from those which originated on the Eastern Jumna Canal, and which have been attended with the greatest succes not only in economizing the supply, and in facilitating the distribution of water to the Cultivators; but in protecting the interests of both the Government and those who are dependant upon the Canals for Irrigation.

The details, will offer a Skeleton for Operations, and a ground work for bringing to completion, that which I have only within the last

last year began; and I shall have explained myself very imperfectly if these details are viewed in any other light than the merest possible outlines, on which one general and comprehensive series of water courses (embracing throughout a free and uninterrupted circulation of current) has been contemplated. —

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PART, III.

Description of the Works and Details of Construction

CHAPTER, I.

Drainage Works

Under this head may be placed..

I.. The Dams and Works connected with them at Myapoor and Dhunowri.-

II.. The Works in the Ganges Khadir for the admission of Country Drainage

III.. The Works for the Escape of Country Drainage

IV.. The Superpassages for carrying the Ranipoor and Puttri Torents over the Canal

V.. The Inlets which form a Component part of the Budges and Rajbaha Channels.-

The first four items are confined to the tract of country lying above Roorkee, and are legitimately speaking the only Works which have been expressly designed for counteracting the effects of the Mountain Torents and drainage subordinate to them; the 5th item although to the extent of their capacity, capable of receiving water that falls in their neighborhood, are designed specifically to remedy

the interruption to the natural ~~escapes of water~~ draining caused by the intervention of the Ramps of Bridges; the benefits to be derived from them, therefore, are merely local, and restricted to the ~~limits~~ vicinity ~~of~~ of the land, lying on the up stream side of Bridge ramps and in the vicinity of the Choki buildings.

I. The Dams, and Works connected with them at Myapoor and Dhunowri.

The works at Myapoor and Dhunowri, although they may be classed under the head of Inlets as well as Escapes for regulating the supply, fall more appropriately under the denomination of Dams and Drainage Works, I have therefore included them in this Chapter, whilst the Escapes which are situated at detached points of the Canal Channel are described in Chapter II under the head of ~~Escapes~~ works for Regulating the supply.

At Myapoor the water reaches the Dam through an open Channel without any Masonry work for its special admission, and by the closing of the Regulating Bridge waterway the whole of the supply which arrives at that point either directly from the Ganges or from the side tributaries, is passed over the Dam without ~~affecting~~ in any way ~~connection with~~ the excavated Channel. Although, therefore the

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the term Inlet may be properly applied to the water on its approach to the works through the open Channel of the Bundwar Branch of the Ganges, it ~~in no ways~~ only affects the Canal works ~~further than~~ those immediately connected with the Dam; in the same Category may be included the Inlet for the Bochna Nulla, which enters the branch on the upstream side of the Regulator; this however is a Masonry Opening with a Waterway of 20 feet in width, ~~and with~~ a fall in the Shape of an Ogee, ~~which~~ forming a part of the buildings attached to the Myapoor works.

At Dhurmoor, the Inlet for the Rutmoo River is a compartment part of the works at that place; it delivers the flood water into the Canal Channel to be passed off by the Dam Sluices which are placed directly opposite to it; the object of the building which forms the Inlet, is to give the power of retaining the Canal supply within a limited Space, which is effected by ~~closing~~ closing the Inlet Sluices during the periods when floods are not running ~~it enables us to do~~; had ~~the attainment of~~ this object been unnecessary, and had the inundation which would otherwise have been consequent on ~~attendant upon~~ the introduction of water into the Canal, been of no ~~consequence~~ importance; the design of the works here would have been similar to that at Myapoor, in so far that the Rutmoo Ch-

= n

=nel on its upstream side would
have been left open and unim=
=peded by Masonry works of any
description. The detail of this
Inlet, therefore, will more properly
belong to the description of the
works at Dhunowri or those on
the Rutmoo River. The Inlets
in fact which are attached to the
Dams at Myapoor and Dhunowri
are altogether peculiar to their
~~positions~~ positions and uses,
and on this account I have in=
=cluded them in the present
Section. -

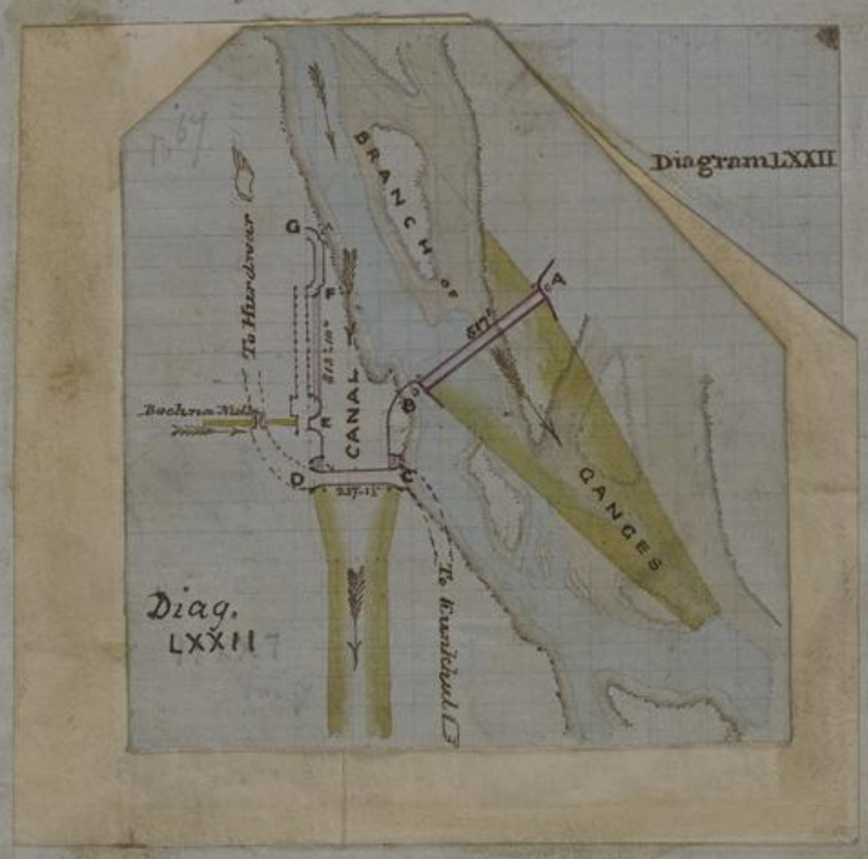
From the above it will be
understood that the works which
come under the head of the 1st
Section, are only two in Number,
they are situated in the Khadir
of the Ganges, one being built
over a branch of that River be=
=tween Bundwar and Kunkul,
the other across the bed of the
Rutmoo Torrent. The purposes
for which they are designed are
to retain the Canal Supply
in its proper Channel, and in
their capacity of Dams to pre=
=vent it from passing beyond
a fixed limit: in that of Outlet
or Escape, they pass off floods
during the rainy Season, and
superfluous water at other times:
at the points, moreover, where
they are built they act as Regu=
=lators to the Canal Supply:
they may be described as Masonry
Platforms thrown across the
bed of the River, with their flanks
well protected, and with the
space between the flanks fitted
with Sluices. - Taking the works
of this description which have been
built

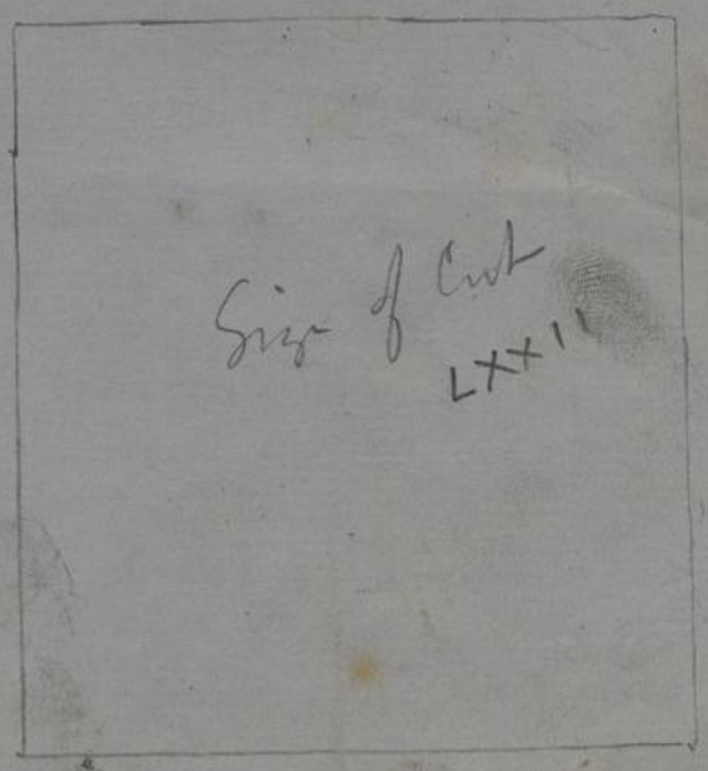
built on the Ganges Canal in their order of Precedence, the first that comes under review is the

Myapoor Dam and dependant Works

The plan of the works which are connected with the departure of the Canal supply from the Ganges River and its Branch at Myapoor, is shewn in all its detail in Plate No XIV of the Atlas.-

The works consist of a Dam thrown across the Branch at a point 3850 feet, below the Town of Bundwar, and at the site of what was formerly called the Gunes Ghat.- This Dam is connected on its right flank by a Curved Revetment Wall with a bridge of 10 Waterways built across the Mouth of the Canal; on the right and upstream side, a line of Ghats and Revetments acts as a retainer to the bank of the River, abutting upon the right wing of the Bridge. The Skeleton of the works may be understood by the following Diagram





The angle of departure, or that formed by the Dam and the canal alignement is equal to 126 degrees; the general dimensions of the ground plan are shewn by figures on the diagram.

The foundations of a great part of the Dam, Bridge and connecting revetments were laid in as far back as the year 1815, under the Executive management of Lieut. Richard Strachey of the Engineers, under whom the whole of the foundations and a part of the superstructure were completed.

Lieut. Strachey left the works in 1816 and was succeeded by Lieut. Yule, who made over charge ~~of the works~~ to his successor Lieut. Alpd. G. Goodwyn in 1818; under the latter officer the works have been brought to completion - The ground plan as originally designed has not been deviated from. The superstructure of the Bridge as well as that of the Ghats and revetments, in fact the whole of the work with the exception of the Dam sluices and their piers was completed by Lieut. Yule, to whom the design of the Bridge Elevation, steps of access to the Ghats, and general outline of the Cornices and String courses is due - The Bochna Nulla, a mountain Torrent of moderate dimensions, is admitted into the works thro' an Archway of 20 feet in width which is pierced through the right Revetment at the point E in the diagram; the water at this Nulla on its reaching the works has a drop of 10½ feet, 2 of which are expended

expended in a head reservoir, offering a concave surface to the current. 268½ feet above the Inlet, the Bochna Nulla is crossed by a Bridge which with the bridge over the Canal act as the connecting links between the Town of Hurdwar and Kunkhul, the works attached to the Bochna Nulla, were completed by Lieut Strachey, and before the period of Lieut Yule's assuming charge of the Executive duties. Immediately in the rear of the line of Ghat which constitutes a portion of the right Revetment, and at a distance sufficient to leave a wide passage between ~~between~~ the Revetment parapets and itself, a second Revetment, broken at intervals by Square and octagon Towers, acts as a retainer to the high land which lies at its back: access is gained to this high land by a flight of steps at the end of the Tower wall nearest to the Bochna Nulla.-

The ~~design~~ of these Towers is derived from buildings of the same description which existed previously to the commencement of the works. ~~From the Town of Hurdwar to Kunkhul~~ A roadway partly paved and evidently of great antiquity ran, ~~with the exception of those points which were broken by the Torrents, continuously along the face of the high bank and parallel to the Bunch of the Ganges. This road was a passage for the Pilgrims, between the two Towns, it was richly wooded, and marked here and~~

from Hardwar to Kankhul along
the edge of the high bank & parallel
to the branch of the Ganges. Its
course was continuous except
only at those points, where the
lateral Torrents broke through
it. It joined the line of
communication between the

~~and there by noble Specimens of the Banyan (Ficus Religiosa) Peepul (Ficus Indica) and other trees loved by the Hindoo~~; under the Shade of these Trees, and at short distances apart from each other were Bytuks, or places upon which Fukeers, and other holy men Sat and received the adula-tions of their admirers. these Bytuks consisted of octag~~on~~al or Square Towers, not exceeding 7 feet in height, approachable by a flight of steps; and frequently situated in the middle of a 'Chubootra' or platform of masonry ~~These Bytuks~~ were in fact the Earthly Palaces of the Fukeers, each had its possessor, and every separate Bytuk had its peculiar sanctity. ~~Each successive year~~ To whatever extent ~~the~~ their intermediate Owner's wan-derings may have led him, whether to the Snows of Gungootri, or to the burning Plains of Dug-gurnath, ~~each successive year~~ exhibited to the ad-miring pilgrim, the same Fukeer sitting in the same Bytuk, in all probability with the same uncombed hair, and with the same ashy, unwashed, and unshaven countenance.—

As a necessary consequence of the Excavations at the Canal head, and their relative position to the bank and road, a num-ber of Bytuks equal to that which has been (unintentionally) pulled down; in rebuilding these advantage was taken of the opportunity to alter the design of placing them as ornamental features in rear of the Bathing Ghats and in the position in fact in which they are

two Towns for the Pilgrims frequenting the Hardwar Fair; has richly wooded, & marked here & there by noble Specimens of the Banyan (Ficus Religiosa) Peepul (Ficus Indica) & other Trees loved by the Hindoo.

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are now situated; this position
is not far removed from that ~~to~~
occupied by them
~~which they~~ originally ~~stood~~, and
a large Bar Bassyan Tree which in all
probability was the centre of attrac-
-tion to the neighborhood, shading
with its gigantic arms the old Bylah
~~necessarily removed~~
~~to which bullocks with the excavations~~
now persons its former office for the
the new buildings, standing on
an esplanade prepared for its
reception, and protected on the
River side by a retaining wall of
Masonry as shewn in the Diagram
at the letter G.-.

I have elsewhere stated that
the Channel which has been ex-
-cavated from the Ganges to the
Myapoor Dam and Regulator,
is 300 feet in width, on a slope
of 8·59 feet p.m. mile, on this slope
also the tail excavation from the
Dam towards the main River
at Kunkhul has been excavated;
the extent to which this has been
carried, is shewn in a purple
shade on Plate No XIII of the Atlas
The different improvements that
are proposed in the neighborhood
of Hurdwar and the bathing
Ghats, with different suggestions
for facilitating ingress and egress
to the water having all been
described in Chapter 2 of the
2nd part, I shall proceed with
the detail of the Dam works,
the outline of which, together
with that of the Branch previous
to its having been touched by
the Excavation, is shewn in the
foregoing Diagram.-

The left flank of the Dam
it

it will be observed abuts upon an island, in which nearly one half of its full width was excavated; the island at the point of contact although terminating at a short distance below the work, is composed of compact earth and shingle, and affords a sound and efficient resting place for the flank walls. The right flank falls within the precincts of the branch as it existed at the period when the works were lined out, and is consequently backed by shingle and soil excavated from that portion of the mouth which lies north of the Regulator: The outline of the Earthwork and Embankments as they now exist are shewn by the yellow lines. The red shade representing that of the Dam, Bridge and Revetments.

The floorings of the Dam and ~~that~~ of the Regulating bridge are laid on one level, and the front line of the latter is the Zero upon which the whole of the Canal Excavations ~~have been carried~~ are measurable. The Zero point was fixed by me on my original Survey, it was in fact the bed of the Branch at that period, as nearly as the calculated bed levels of the Canal between the head of the 1st Set of Falls at Bahadoorabad, and the foot of the Gunes Ghat before alluded to, would admit of.—

The Slopes of the Branch Channel

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Channel from the Ganges to the flooring of the Myapoor Regula=ting Bridge is, as I have before said 8·59 ft per Mile. That of the Canal Channel below the Bridge 2 feet per Mile; the change of Slope therefore, is a very remarkable one, the beds of all the Rivers consist of large and small boulders, and the supply of water throughout the whole of the Year, excepting during floods, is pure as crystal. The effects upon the Canal bed on the up stream side of the Dam, as well as along the line of the Canal from its mouth downwards will doubtless be shewn by deposits which will be increased by the influx of Sand and Shingle brought down in the Delta Rivers; in a minor degree deposits also will be due from the Bochna Inlet, I believe that such deposits are unavoidable, and that periodical clearances will be required; their effects, however, will not be prejudicial to the main=tenance of supply.

The Dam itself which is 517 feet between the flanks is pierced in its centre by 15 open==ings of 10 feet wide each: the Sills or floorings of each opening being raised 2½ feet from the Zero line, these floorings are so con=structed that, if necessary, they may be removed, and a flush Waterway be obtained as low as Zero; the piers between the above openings are 8 feet in height, so that the elevated flooring, leaves the depth of sluice gate, equal to

5½ feet

5½ feet; the piers, however are
filled with grooves for the admission
of sleeper or vane planks, to which
I propose restricting the appara-
tus for closing the Sluices, until
experience has been gained, of
the effects of deposits on the up
stream side of the works, and
the advisability or not of main-
taining the Raised Sill to the
openings: there are great advan-
tages in the Sill being raised
with respect to facilitating the
opening and shutting of the
Sluices; the arrangement also
reduces the gates to a moderate
height, and consequently to a
more manageable dimension
for working; it admits, moreover,
of the Sluices being opened and
closed in a much shorter period
of time: Opposed to these advan-
tages, however, is the certain
consequence, I imagine, of deposit
arising from a bar of masonry
raised 2½ feet above the true level.
The adoption of this bar, it will
be understood, is purely ex-
perimental, and should its
existence be found hereafter to be detri-
mental to the works, it can be
removed.-

The Centrical Sluices above
described are connected to the flanks
by Overfalls rising in gradations
of one foot on 3 Series, the overfall
nearest to the flank being raised
10 feet above the Zero point. The
flank walls themselves are 18¾
feet in height exclusive of com-
ice and parapet, which rise 5
feet above them. The top of the
overfalls

overfalls on the right and left, as well as that of the piers is flat, the former being an esplanade varying from 7 to 10 feet in width, which during dry weather is connected by a temporary communication formed by planks thrown across the sluice openings. This esplanade is at each extremity terminated by a flight of steps which gives access to Store rooms, in which when the Dam is laid open, and the woodwork removed, the latter is lodged for security. The two buildings for this purpose are situated on the flanks, their floors are raised 20½ feet from the Zero point, and their interior dimensions ~~is~~ are 30'×16'

The flank revetments which are built on the right and left of the down stream side of the Dam, and between which the Escape water has to pass, have been designed with an inclination inwards equal to 13 feet on a length of 80: the principle on which a wall placed in this direction is supposed to act, is fully described in the Chapter on Falls, as in the tails of those works, it has been carried out very extensively; its main object is to keep the current in the centre and away from the sides, and it is more economical in its construction.—

The transverse width of the Dam platform is 45 feet measuring from the up to the down stream face of the work,

of

of this measurement 20'. 11" are given to the tail which delives the water upon the natural bed of the River, consisting of large boulders and shingle.

The revetment which connects the right flank of the Dam with the regulating Bridge is a plain wall Equal in height to the Dam flanks, and with a slope or batter of 2½ in 20 feet in height. This Revetment on its approach to within 50 feet of the Bridge terminates in a line of Ghat, or flight of steps which passes from the higher levels to the bed of the Canal The upstream wing or flank of this flight of steps corresponds in form with that of the wing of the Bridge, with which it has a uniform curve.

The Regulating Bridge has 10 Bays or Openings of 20 feet wide and 16 feet high each; each bay being fitted with shutters and apparatus for either opening or closing it. The breadth of the platform on which the piers rest is 48 feet exclusive of the Cut waters which project 6 feet beyond it. The Roadway is 37'. 9" wide between the rear parapets, and the up stream front windlasses; it acts as the main line of communication between Burdwan and Kunkhul

My design for Regulating Bridges has invariably grooves appended to both the up and down stream faces of the Bridge;

the

the latter are useful when ac=
=cidents occur to the front gates
or to the apparatus for using
them: and they provide an
alternative which without
them does not exist: in the
present case the deviation from
the original design for the super
=structure to which I have before
alluded, has deprived us of these
accessories, and it was not pos=
=sible without a total recon=
=struction of the rear face of
the bridge to restore them. The
design of Shutters for closing
the Regulators is different to that
which has been practised on the
Jumna Canals, it affords much
greater facilities for working, and
secures either the closing or the
shutting of the bays in a much
shorter period of time: both of
these objects are of great consider
=ation when we are opposed to
the immediate action of the
Ganges, the extreme high water
being agreeably to a register
kept for the last 12 years equal
to 15 feet upon the Zero line.

On the Jumna Regulators
a drop Gate is ~~passed~~ down
a simple groove, and sleepers
with a scantling of 6" square
are dropped upon the top of
the gate, both time and labor
are required to close or open the
bays when fitted with apparatus
of this sort, but it has always
acted very efficiently, and op=
=posed to the Jumna floods has
done its duty very well. It
must be recollected however that
on the Jumna Canals we have
neither

neither the same volume of water to contend against, nor the same number of bays to open and shut that exist on the works which we are now describing: it was necessary with 10 bays upon which the safety of the works depended, to devise some quicker method than that which acted for 3, and if possible to economize the labor required for using the appariatus. The following diagrams will shew in vertical section the method which is in use on the Summa, and the improved method which I have adopted in the present case.-

Diag: LXXIII.

Fig: I.

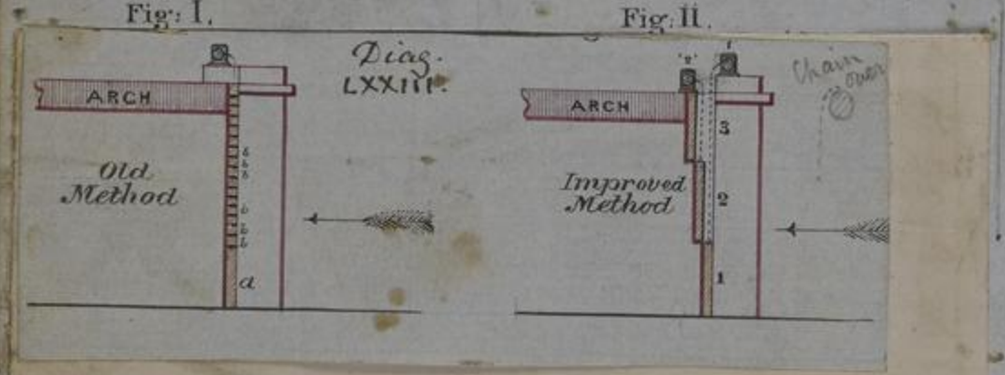

Fig: II.

Fig: I it will be observed represents the groove and its cutwater opposed to the upstream current 'a' represents a gate 5 feet in depth which is kept suspended in dry seasons, and is dropped down on the expectation of floods: b.b.b. shew the sleepers or long bars of timber, which when the chains are removed from the gates, are successively dropped upon them until the bay is closed; the time that this takes is equal to 18 minutes the whole operation has been frequently carried on in my presence

Fig: 3 Cut.

The blue dotted line which represents the chain, right from the circle (which represents a section of the windlass) perpendicularly thus

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presence, and the period taken has been accurately timed, the perfect efficiency of this species of shutter, in the hands of our native Establishment has been tested by me, by actual residence on the spot during the rains, and by personal superintendence of the machinery.

Fig: II. shews the improved design, gained by the use of 2 windlasses. The bay or opening it will be observed, is divided into 3 series, the more advanced one having its sill on the Zero level, the centricial and rear ones having their sills elevated in heights of 6 feet retrograding towards the face of the bridge. The shutter marked No 1 is dropped from a windlass on the Bitt head '1'. that marked No 2 from the Bitt head '2'; that marked No 3 consists of sleepers which are raised and lowered without the aid of a windlass. the 3 gates therefore are quite independent of each other; each has its own sill to rest upon, and the whole can, if necessary, be worked simultaneously. The great advantage of this method will be understood, by supposing that a supply of water not exceeding 6 feet in depth is required for Canal purposes. In this case the whole of the shutters 2 and 3 may remain closed, and when floods come on, the whole of the waterway may be stopped by releasing one set of gates only.

Supposing again, that the

the maximum supply of 10 feet
in depth is passing down the
Canal, and that to admit of
this, it is necesary to have both
the No 1 and No 2 Shutters raised,
No 3 will still remain closed;
and as both No 1 and No 2 Shutters
are suspended on separate wind-
-lasses, both can be simultaneously
relieved, to the effective and almost
instantaneous closing of the
whole of the Regulator. It will
be necesary for navigation pur-
-poses 2/ to have one 1/ of the bays
with its shutters open 1/ (dependent on
the head way required for boats) 1/
but as during flood periods,
neither boats nor rafts are likely
to frequent this part of the river
no inconvenience ~~interference~~ from this source
need be anticipated. The ma-
-chinery attached to these gates
is of the most simple description,
intelligible to the commonest
laborer on the works, and not
liable to disarrangement: it
consists of ~~plain~~ windlasses
which work in sockets, embedded
in wooden bitt heads with
~~plain~~ ratchet wheels and catches
the windlasses being turned
by ~~hand~~ hand spikes; the chains
are on the bar principle in
lengths of 3 inches with plain
rivets, and the shutters are mere
planks, sliding upon iron rods,
held at their lower ends by nuts,
and terminating above by rings
countersunk for fixing the chain
upon; The wood used is Sal
(Shorea robusta) the staple
timber of the Sewalik forests. —

The

Alder

The above will with the addition of Plate XIV of the Atlas give a full exposition of the Dam and Regulating Bridge; it being understood that when the Shutters of the latter are down and the bays are closed, the water is passed off through and over the Dam, the sluices of that work being opened for the purpose; the System, therefore, of admitting and Regulating the supply of water into the Canal head by the works above explained, will need no further ~~explanation~~ detail.

I have before noted that a Ghat or flight of steps is the connecting link on the left between the Dam Revetment and the Regulating bridge. A Ghat identical both in design and dimensions is also ~~corresponding by~~ symmetrically situated on the right; from the upstream flank of this Ghat a straight line of Revetment on proportions similar to that on the left or opposite side of the Canal, meets by a curve on its extremity the Inlet of the Bochna Nulla, the canal face of which is equal to 50 feet in width; A corresponding and semicircular curve gives a limit to the Inlet works on their upstream side and connects them with a line of Ghat of 385 feet in length. The Ghat ~~which~~ is approached by a flight of steps placed centrically on its length, and abuts at the upstream end, upon

upon the Tukee's Revetment. This
~~Copy wall~~ Revetment with a species
of berm or faussebrau on the Canal
side, ~~was~~ built for the protection
of a Masonry platform, from the
centre of which a Bau tree, ~~to~~
~~which I have~~ before alluded to, rises.
This Noble tree is well protected
on the Canal face by the existing works
~~which have been built~~, and the
line of Bastiks ~~I~~ I have
described as constituting a part
of the Revetments ~~which forms~~ in
rear of that of the Ghut face, ~~and~~
~~in lieu of others which it was~~
~~necessary to remove for the purpose~~
~~of laying out the works~~, restores
to a certain extent, a harmony
between the works ~~that have~~
~~been~~ recently built, and those
which existed on the ancient line
of paved roadway.—

The Tukee's Revetments and the
building for whose protection the
works in its neighborhood were
designed, are much elevated in
position. Although at a distance
of only 417 feet from the horizontal
esplanade on which the Regula-
ting Bridge and other works at-
tached to it are laid out, the rise
to the Tukee's building is 10 feet
In my original plan for this
work the difference of levels was
gained by a slope, or inclined plane
ascending from the Bocking Inlet
to the Tukee's building:. Upon this
plan the work has been completed.
it has led to exceeding awkwardness
of design, and in a general point
of view to great ugliness of ele-
vation, the leading cause of which
is an absence of Parallelism in
the

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the composition, the upper line being on a slope, while the lower one is horizontal. It would have been better in all probability to have continued the Esplanade on one level to the foot of the Turkee's buildings, and at that point to have given steps of ascent to the front and a ramp to the rear. The whole of the work however was completed before my return from England in 1848, and it was not thought worth while to make alterations which would necessarily have been very expensive ones, and after all would only have been an improvement, in so far as Elevation and appearances were concerned. This part of the work therefore has been left in the state in which it was originally built partly under the design of Lieut Strachey, and partly under that of Lieut Yule; the whole having been completed by the latter Officer.—

I may observe in Conclu-ding my Remarks upon these buildings that it would have been both unwise and unnecessary to have raised the Roadway of the Regulating Bridge, and by this method to have placed it in closer correspondence with the level of the Turkee's buildings and of the Embankments on the down stream side which are also much elevated con-sequent on the enormous ex-

-tent

=tent of the Canal excavations.
It is our object to limit the ex
=tent of waterways in the Regu
=lating Bridge, to that capable
of admitting the required supply
and of giving free and unim=
=peded passage to boats; beyond
this every additional Square inch
of waterway not only is unnecessary: but is a positive evil
would, therefore, be the desire
rather to diminish than to in=
crease the height of the bridge,
and to depress rather than to
elevate its roadway: The want
of Elevation, however, has led to
the necessity of the awkward
ascent to the Tukeei's building,
and on the down stream side
of the Bridge, to as awkward an
inclination of the roadway Em=
=bankment, to meet the bridge
roadway levels: in fact with the
exception of the esplanade be=
=tween the Bridge and the Dam,
and the roads of approach from
the Country which are all on one
horizontal level, the bridge is
reached by downward descents
which although on small angle
~~add~~ by no means ~~improve the~~ ~~to the beauty=~~
~~=ful to~~ appearance of the works
Plate No: XIV of the Atlas
enters very much into detail as
to the construction and to material
used, in the building of the
Myapoor works.—
In laying in the foundations
of the Dam and Bridge which
were in progress previously to
my leaving India in 1845, Spring
waters

water was met with, leading to great inconvenience; these founda-tions which consist of unbroken curtain walls with cross bars be-tween them, were sunk to a depth of 6 feet, and built entirely of boulders and cement. A great portion of the massive part of the superstructure of the works was also built of the same material with brick bond as represented in Fig: 6. where boulders were not used bricks were ~~brought into requisition~~ employed, and of this ma-terial the whole of the facings and more delicate parts of the structure were made: The steps of the Ghats and approaches there-unto, are faced with ~~the~~ Sand Stone procured from the hills in the neighborhood; a material of very uncertain quality, and which as a rule I have rejected from the works; this Sand Stone has been used in the bridge in a variety of ways, most beneficially in my opinion in the Grooves, the diffi-culty of attening which to adapt them to the regulating Shutters affords a fair exhibition of the strength of the material; ~~after carefully selected~~ The whole of these works are stuccoed with a Cement of the following proportions

1 Part Lime (Stone)
1 -a- Soorkee

The proportions of Cement used with the different species of masonry are as follows

Boulder Masonry	Brick Masonry
1 Part Stone Lime 1 -.- Soorkee 1 .. Sand	1 Part Stone Lime 1 Part Soorkee

The Total amount of Materials expended in these works is shewn in the following table, to which is appended the rates at which the different varieties of work were executed

Total Cubic Contents of Masonry.	520101	cubic feet

Materials expended

Bricks. 12"x6"x2½"	364821	
Do — 12"x6x2"	535744	
Do — Small —	2700	
Boulders	335000	Maunds
Stone Lime	98690	Cubic feet
Sookee	96991	do

Brick Masonry -	19	10	5	for 100 Cubic feet
Boulder - Do —	9	"	5	for do
Plastering	6	5	11	for 100 Sft feet

Small as the Arches ~~are~~ of this Regulating Bridge are, they appear to have been constructed with wooden Centerings, instead of on the ~~Cheaper~~ effective and economical method adopted by the Natives; the results have been curious, the cost per 100 Cubic feet of Arched Masonry including the centerings and contingencies thereunto attached having been Co Rs 35.1.9 This heavy charge is of course owing to the whole of the cost of the Carpentry and woodwork of the centerings being chargeable to this work alone: there were no other Arches of ~~the~~ this dimension in the ~~works~~ excepting in the Regulating Bridges, of which that attached to the Rutmoo ~~works~~ was the only one in the neighborhood, and to this the wood work referd to could only have been transported at a ~~ex~~ enormous cost. It will be seen by the Summary of rates on ~~the following~~ those books that the use of earthen centerings produced a rate for the Archwork per 100 Cubic feet of Co Rs 19.5.11 only.

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pt 3

Diag: LXXV

DHUNOWRI WORKS

Shewing the position of the Masonry Works with reference to the Rutmoo River and the method to be adopted in directing the Stream of that River upon the main Works

The Blue Tint shews the extent of Inundation in the Rutmoo valley, with a depth of 10 feet in Canal
The Blue Figures, the depth of water The Red Figures, the height of land above the surface level of Canal
The Dark purple tint shews the 3 Cuts made Previously to the rains of 1852 so as to allow the floods of that year to act on the intended bearing

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The Dhunowri Works.

These works consist of Dam and Inlet thrown across the Rutmoo Torrent, a Regulating Bridge and Bridge of cross communication in connection with the Canal Channel and Revetments with a variety of drainage works appended to them. - They are situated between the 13.th and 14.th Miles from the Myapore Regulator, and below the great descent that takes place in the Canal bed levels in the region between the Ramjoor and the Puttri Torrents. - In exhibiting a Skeleton of the works which are connected with the Rutmoo River, I shall be able to introduce the details with greater precision

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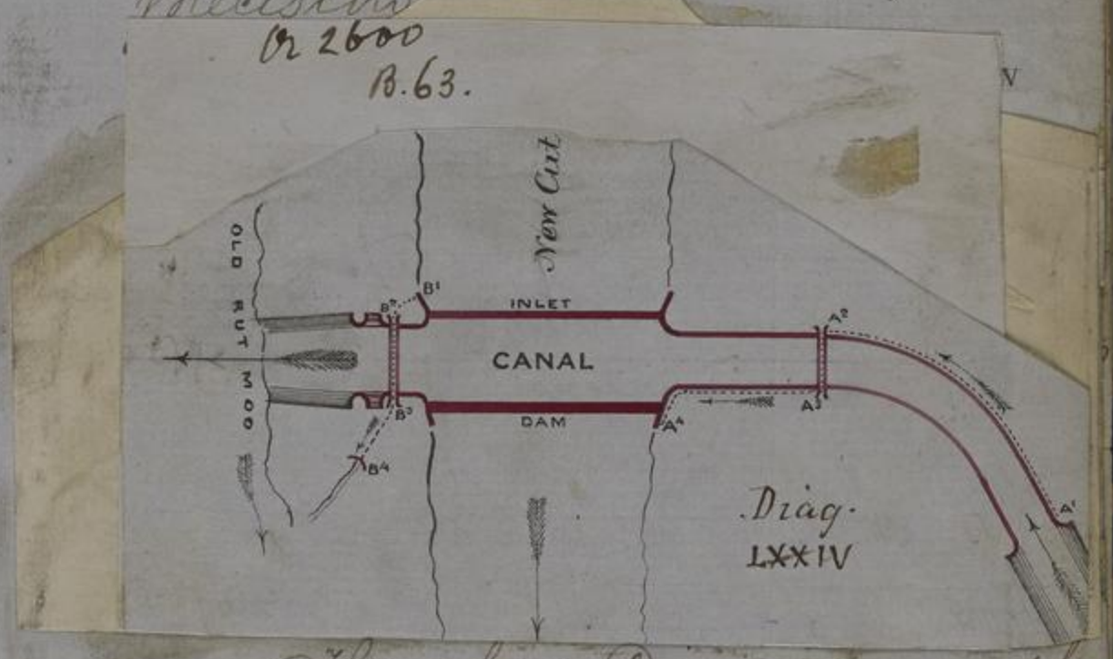

The above Diagram, with the Map of the Rutmoo River in the neighborhood on the opposite Page, will ~~about of~~ lead to a full understanding of the whole question. —

In an early Chapter, the causes which ~~led to~~ determined the peculiar lining out of the above works have been described; the circumvallations on the up Stream side

of

of the Torrent consequent on the absence of works for their prevention have been especially referred to; it was suggested that a well managed Inlet with efficient drainage might entirely relieve the Country from inundation and that it was possible when ~~forming~~ the works ~~into Execution~~ were in progress, means might be discovered for perfecting the design in such a way that all the desiderata required should be obtained.- I believe ~~that~~ this has been done, and that the works as constructed, will relieve the Country from inundation, and at the same time give a free escape to any water that may either come down the River, or find its + way by leakage under the + works.

The Canal at its intersection with the Rutmoo River, meets it on its own level, the Sills of the different works therefore are on the level due to the ~~Practical~~ particular Slope of the Canal bed, calculated on the distance from the Zero at the Myapoor Regulating Bridge.-

The Rutmoo with the exception of a short period of dry weather before the annual rains set in, may be considered a perennial Stream, carrying a very small body of water, but still sufficient to maintain the above character. In the driest weather, and when there is no

observable

observable Stream, Spring water is found immediately below the surface. The area of the Catchment basin is 126 Square Miles, its extreme length may be estimated at 21 Miles. Of the most Northerly portion of which ~~are~~ is mountainous, and the remaining Jungle and Forest;- its average width is 6 Miles. The effective slope upon the works is 8 feet per mile.

The width of the Rutmoo valley at the point where the Dam is built is One Mile, and the section of the Channel of the River itself is shewn by the following Dia.=gram; This section exhibits the highest observed floods which took place on the 21st July and on the 29th September 1850. and shews the State of the bed of the River both before and after the floods, offering a fair exhibition of the muta=bility of the courses of these Torrents ~~Rivers~~ during the rainy periods.

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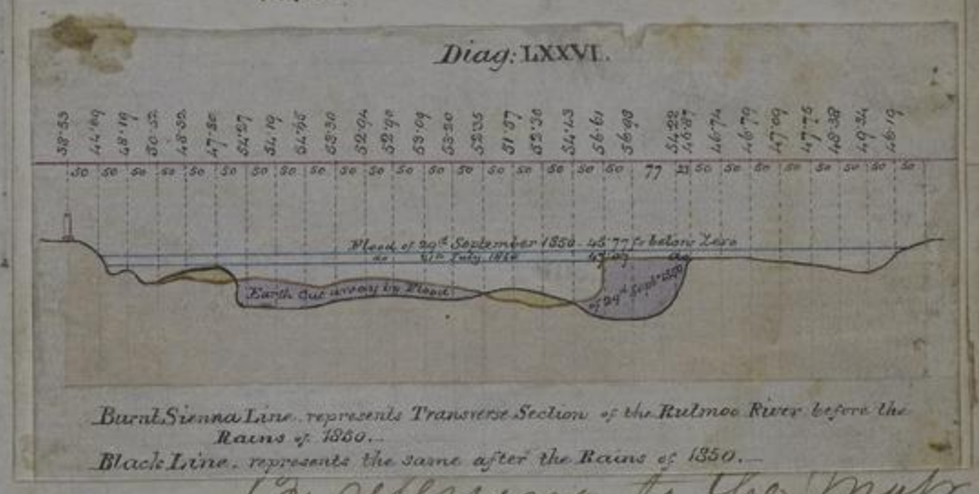
B.66.



Burnt Sienna Line. represents Transverse Section of the Rutmoo River before the Rains of 1850.
Black Line. represents the same after the Rains of 1850.

By referring to the Map it will be seen that independently of the Torrent itself, which passes on the left, a minor Stream runs under the right bank of the Valley; this little tortuous Nulla the bed of which is 4 1/4 feet below that of the Rutmoo itself, is one of those lines of drainage which I have before ~~described explained~~ as

Size of Cut and Stave for Type for reference

as the usual appendage to all the Khadir lands of the Mountain Torrents, its bed is to all appearance carved out of a hard soil, giving Rice cultivation to its neighbourhood; its course is full of Springs, and it is marked by "duldul's" or quicksands.-

The blue tint on the Map represents the area of surface that would be inundated, supposing that the Dam was closed, and that the maximum height of 10 feet of water was passing down the Canal, without the interven-tion of a work for confining it the volume within its proper Channel, or in other words supposing that no Inlet had been built. The figures represent the depths ~~either above or below 10 feet, or above the level of the Dam floorings~~ of water on the inundated surface blue or & the height of Dry Land above it elsewhere.

It will be observed that the Site of the work is 300 feet to the left of the Natural Channel of the Rutnoo River, an arrange-ment which admitted of the annual Torrents passing off during the progress of our opera-tions without interfering with either the Excavations or material

The position in which the works are built necessitates a change in the course of the River, the lining out of which is shewn in the Map; a System of trans-verse Spurs or Embankments identical with that which has been put in practice at the Puttri, has been carried out on the approach of the new cut to the works; the deep section of the Bhuguleea

has been

been filled in and cuts have been made from the low ground in its neighborhood towards the

main Torrent for the purpose of relieving the right side of the Valley from inundation. The Spurs which abut on the right

bank will it is supposed lead ultimately to the warping up of this side of the Valley.

The Canal embankments which connect the Regulating Bridge with the highland on the Peeran Kulleen ridge, have (with exception of that taken from the Channel which bears a small proportion to their extent) been made from earth brought out from the deep digging through the ridge; the length of these Embankments is equal to 5000 feet, and the work has been done entirely by the aid of rail roads and Earthwagons. At the debouche from the deep digging the Esplanade on the top of these Embankments has been made of extraordinary width and in a form which is shewn in the plan, the object being to cover the Bluegulecca by as great an extent of raised Embankment as was possible. The Embankments on the right or those which are more directly opposed to the Rutmoo Torrent have also had increased height and width given to them

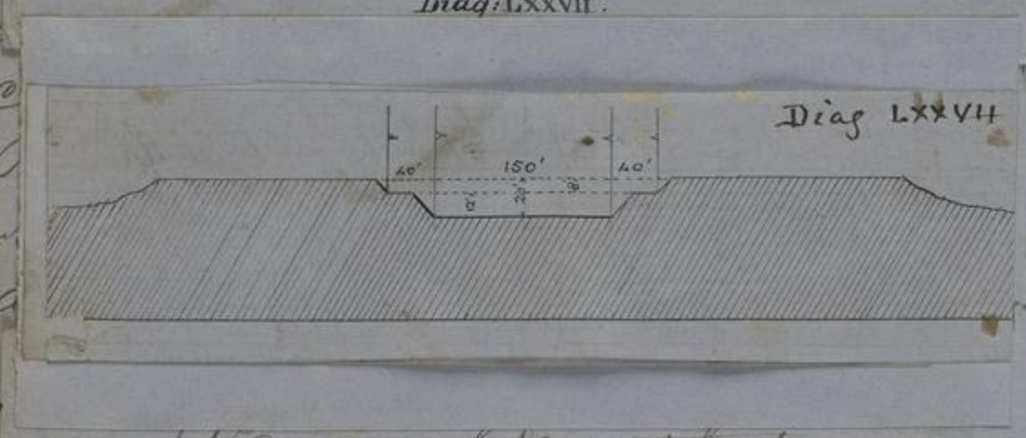
The

which lies between the Rutmoo works and the Peeran Kulleen ridge

of

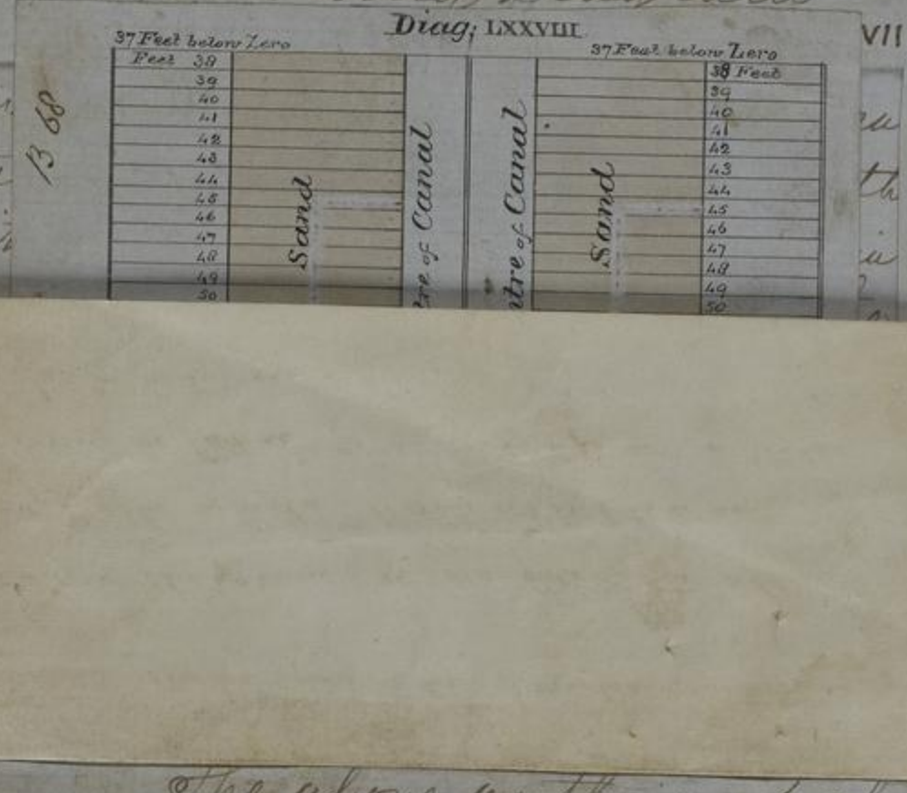
Ridge is as follows.-

Diag: LXXVII.



I may observe that in Excavating the Channel from A' to A" vide Diagram LXXIV, Spring water was met with at depths varying from 7 to 10 feet from the Surface, a circumstance to which I would draw particular attention, from the influence that it had upon the designs as connected with drainage. The position of Springs with reference to the Surface of the country on the line from the Myapoor Regulator to the high land of the Doab at Roorkee is shewn in Diag CLXVI Chap: X. The result of the Boring ~~operations~~ Apparatus on the site of the Rutmoo works is shewn in the following Diagram

Diag: LXXVIII.



The above outline of the main peculiarities attendant upon the position of the Rutmoo works

was

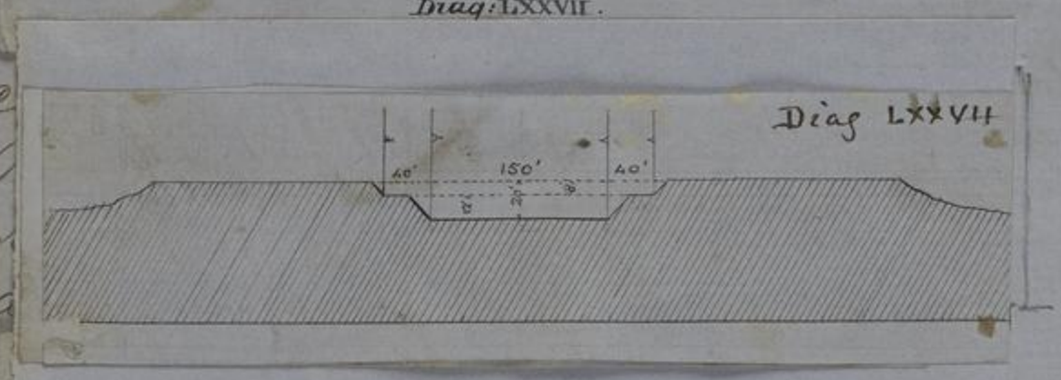
Sir J Cut

works will enable the reader to comprehend the detail which I am now about to enter upon, and to appreciate the difficulties that were overcome, and the final success that attended the assistant Engineer in bringing the ~~whole works~~ to a completion.—

The Rutmoo works were commenced in the early part of 1850, under the management of Mr. Thomas Logan, who on the completion of the 1st Class Choki made Dhunaori (the name of the Estate in which the works are situated) his Head Quarters Station. The position of the Brick fields, the connecting line of Railroad, and all economical arrangements regarding the carrying on of the works, were left to Mr Logan's management, their general detail is figured in the Map. The ~~proximity~~ proximity of the Brick fields not only to the works themselves, but to the excavated channel of the new Escape from the Dam has been of the greatest possible advantage. The brick soil although not found in great quantities in the Channel excavation, was procurable in the immediate neighborhood where it was in sufficient abundance to enable us to maintain a Set of Puzawas or Native brick Kilns ~~of 6~~, as well as a Series of 22 English Kilns. The Bricks for the latter were made by hand on Masonry platforms; and the native kilns were supplied entirely by one of

Ridge is as follows.-

Diag: LXXVII.



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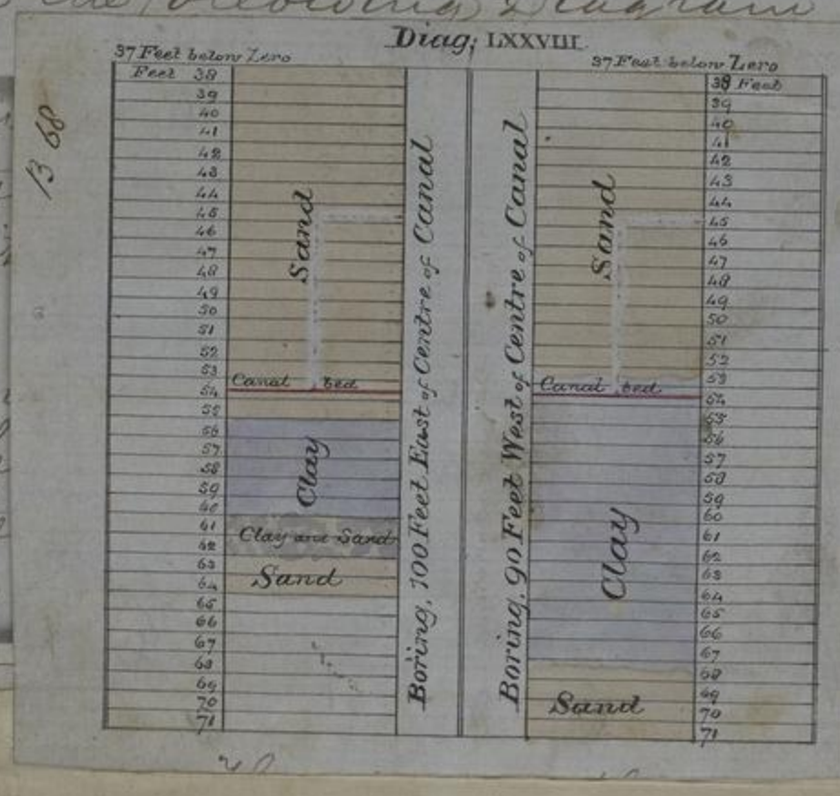
Diag: LXXVIII.



Note for the printer

This diagram is divided to allow of the words "Boring 100 feet E" and "Boring 90 feet W" to be set up and a rule put between.

works will enable the reader to comprehend the detail which I am now about to enter upon, and to appreciate the difficulties that were overcome, and the final success that attended the assistant Engineer in bringing the ~~whole works~~ to a completion.—

The Rutnoo works were commenced in the early part of 1850, under the management of Mr Thomas Logan, who on the completion of the 1st Class Choki made Dhunowri (the name of the Estate in which the works are situated) his Head Quarters Station. The position of the Brick fields, the connecting line of Railroad, and all economical arangements regarding the carrying on of the works, were left to Mr Logan's management, their general detail is figured in the Map. The ~~proximity~~ proximity of the Brick fields not only to the works themselves, but to the excavated channel of the new Escape from the Dam has been of the greatest possible advantage. The brick soil, although not found in great quantities in the Channel excavation, was procurable in the immediate neighbourhood where it was in sufficient abundance to enable us to maintain a Set of Puzawas or Native brick Kilns ~~about~~, as well as a Series of 22 English Kilns. The Bricks for the latter were made by hand on Masonry platforms, and the native kilns were supplied entirely by one of

of Ball's Brick making Machines, the advantages of which have been explained under the head of Materials - After lining out the Brick fields, and fixing the position for the Kilns, the Brick manufactories were con=signed to the charge of the Executive Officer of Materials, who deputed an European Over=seer for their superintendence

When the works had been lined out, and excavators had been placed upon them; ~~the Engineer~~ first object was to dis=cover in how far it might be lowered the Spring water level, by taking advantage of the natural declivity upon which the River runs, in carrying a ditch or trench, on a reduced slope from the foundations on a course corresponding with the direction of the current. The natural slope of the bed was 8 feet in a mile. ~~It was supposed~~ It was supposed that by giving the bed of a trench a declivity equal to 2 feet per mile the Spring level might be reduced to at least 6 feet, and by these means, ~~commence~~ the laying of the foundations might be commenced at an equal depth below the water level. —

The accompanying Sketch shews in plan and Section, the drainage works that were executed on the above principle; and which during the whole of the operations performed their duty most ef=ficiently. The Spring water was

reduced

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Sys of Cut.

reduced 6·25 feet below its natural level, which with the further aid from baling, enabled us to lay in the foundations in some cases to a depth of 10 feet without interference from water, and it secured a system of under drainage across the line of canal ~~thereby~~ ~~obtained~~ providing a remedy for the evils of upstream inundation, which could by no other plan that I can see have been ~~so~~ obtained ~~accomplished~~.

The drainage cut it will be observed commenced on the left upstream side of the canal excavations for the Dam works at the point A. It took the curve upon which the Dam Escape Channel was hereafter to be excavated, and ran for a distance of 6000 feet to a point in the bed of the River, just below the junction of the Baushahpoor Nulla. It was originally excavated on a width of 10 feet which was (as the foundations increased in depth) gradually increased to 20, and with a slope of 1·5 feet per mile. On this level it struck out on the surface of the bed of the River at the letter B. The Cut in its course down the bed of the Torrent was protected by embankments strengthened at every 200 feet of its length by short returns or spurs, a similar protective measure was adopted at its point of contact with the Baushahpoor Nulla. The width originally projected

of Ball's Brick making Machines, the advantages of which have been explained under the head of Materials - After lining out the Brick fields, and fixing the positions for the kilns, the Brick manufactories were con-=signed to the charge of the Executive Officer of Materials, who deputed an European Over-=seer for their superintendence

When the works had been lined out, and excavations had been placed upon them, ~~the Engineer~~ first object was to dis-=cover in how far it might be lowered the Spring water level, by taking advantage of the natural declivity upon which the River ran, in carrying a ditch or trench, on a reduced slope from the foundations on a course corresponding with the direction of the current. The natural slope of the bed was 2 feet in a mile. ~~It was~~ supposed that ~~it might~~ by giving the bed of a trench a declivity equal to 2 feet per Mile, ~~reduce~~ might be reduced the Spring level to at least 6 feet, and by these means, ~~commence~~ might be commenced the laying of the foundations, at an equal depth below the water level. —

The accompanying Sketch shews in plan and section, the drainage works that were executed on the above principle; and which during the whole of the operations performed their duty most ef-=ficiently. The Spring water was reduced

Note for the printer

C. C. Drainage cut
D. D. Bund to protect drainage cut
E. E. Excavated
F. F. To be excavated
H Bedhatpoor Nulla.

reduced 6·25 feet below its natural level, which with the further aid from baling, enabled us to lay in the foundations in some cases to a depth of 10 feet without interference from water, and it secured a system of under drainage across the line of canal, ~~thereby~~ ~~which~~ providing a remedy for the evils of upstream inundation, which could by no other plan that I can see have been ~~done~~ obtained ~~accomplished~~.

The drainage cut it will be observed commenced on the left up stream side of the Canal excavations for the Dam works at the point A. It took the curve upon which the Dam escape Channel was hereafter to be excavated, and ran for a distance of 6000 feet to a point in the bed of the River, just below the junction of the Baushar Poor Nulla. It was originally excavated on a width of 10 feet which was (as the foundations increased in depth) gradually increased to 20, and with a slope of 1·5 feet per Mile. On this level it struck out on the surface of the bed of the River at the letter B. The Cut in its course down the bed of the Torrent was protected by embankments strengthened at every 200 feet of its length by short returns or spurs, a similar protective measure was adopted at its point of contact with the Baushar poor Nulla. The width originally projected

=jected was found to be insuff=
=icient in Sand excavation +
where the action of the Spring +
water had to be contended against,
and latterly it was extended to
20 feet, and even to 25 feet at points
where the action ~~of~~ the Springs ~~water~~
was most energetic. From the
nature of the Soil through
which the Channel had to be
maintained, which may be
described as Sand ~~impregnated~~ Saturated by
~~with~~ Springs, it will be under=
=stood that this trench was only
maintained in an efficient
State by constant clearance, and
by very attention being ~~directed~~ given
to the regular flow of the water
from the foundations; the small=
=est remissness on the part of the
clearing parties, had, in fact, a
ready indicator in the State
of the high water mark upon
the foundations in progress, and
it was quite impracticable to
be indifferent to the maintenance
of a work on which all progress
depended. During flood seasons
the protective Embankments were
necessarily injured, and portions
of the Cut itself filled up; such
events were inevitable from the
very position of the works
situated as they were in the
course of the torrents itself.—
Whatever the difficulties might
have been, and however vexa=
=tious in the detail of progress,
the ultimate success has been
most remarkable.—

One very great point was

gained

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gained by the succesful main-
=tenance of the drainage line;
laying aside the advantages in
an economical point of view of
obtaining 6·25 feet in depth of
building free from the interruptions
of water, it gave us the means of
draining the country lying on
the right bank of the Canal, by
Masonry Channels carried under
the Canal itself; and it instantly
removed one of the greatest of all
our impediments: it enables
us to relieve the upper side of
the Rutmoo from inundations,
and to protect to a certain extent
the Revetments which were con-
=nected with the Springs, from
the injurious ~~tendency that the~~
action, the latter might have upon the
Masonry work.-

Having described the most
interesting preliminary points
of this undertaking, we now come
to the ~~Period~~ time when Masonry work
was commenced, and when the
Curbs or Keenchunks for the blocks
were laid down. The abrupt
curve which the Canal takes
on its approach to the Rutmoo
is tangential to alignements
which meet each other at an
angle of 117°. 14'. 10"; this curved
Channel is protected on each
side by Masonry Revetments
which abut upon a Bridge of
Cross communication. Below
this Bridge the line bears directly
upon Roorkee, and the Canal
proceeds forward to the Rutmoo
between Masonry Revetments
of a similar description to

those

those on the upstream side of the Bridge. The Rutmoo is crossed by two parallel Platforms filled with sluices for the ingress and egress of the Torrent, the Platforms having their flanks well protected and ~~to a consider-~~ built extensively ~~able extent with those with that of~~ the Revetments which on the upstream side connect them with the Bridge of Communication as above noted and on the downstream side with a Regulating Bridge. To the tail of this Regulating bridge, flank protections have been given in the shape of Ghats, and the whole outline of the works which will be better understood by reference to Diagram LXXIV. has been fortified by the strongest available means in Pile and Rubble work.

The torrent which crosses the Canal at right angles to its course, has, on the Plan above described, to enter the Canal Channel through the sluices of the Inlet or work which is built parallel to the Dam. This Inlet consists of a Masonry platform provided with sluices, which at all periods excepting when floods are running, are closed by gates, the Canal water in the Clatter case being confined to its own Channel. It will be evident that were there in the Clatter case above noted no means of escape for the stream that comes down the River, or for the water that must to a greater or less degree leak through the Inlet; this Inlet would act as a

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a Dam for the retention of the water, and would be the means of forming an extensive inundation on its upstream or Torrent side. The success with which Mr Logie's drainage cut before described, has acted in lowering the level of Spring water, has enabled me to provide for the above contingency of inundation by carrying subterranean Channels underneath the Canal, so that when the Inlet is closed, and the Canal supply is in full vigor the water that is derived either from the dry weather stream of the Torrent, or from leakage, can pass off and escape down the Channel of the Rutmoo, without any interruptions leading to inundations. This system of underdrainage has been adopted ~~in~~ both in the case above mentioned, and in ~~that of~~ relieving the Revetments from Spring water: the benefits derived from it therefore divide themselves under two heads.

1st The relief of the Rutmoo valley above the Canal works, from the water which would collect in large quantities both from Canal leakage and from the running stream of the River.

2nd The relief of the Right Revetment from the injurious effects of Spring drainage at its foot.

Under the first head and referring to Diag: LXXIV, a drain (or double drain as it consists of

of 2 channels of 7 feet wide each)
B^1 B^2 B^3 B^4 with its head B^1 on the upstream side of the valley passes under the Canal and through the foundations of the Regulating Bridge; the escape of the drain at B^4 is connected with a cut which carries the water off to the lower levels at a point alto-gether free from the deposits of the Torrent. Under the second head, the letters A^1 A^2 A^3 A^4 shew the position and direction of a Masonry drain which forms a component part of the Revetment, it commences at A^1 and is carried on a rapid slope along the rear and at the foot of the right Revetment to A^2, the drain then passes under the Canal and through the Bridge foundations, turning to the right it then proceeds along the left Revetment from A^3 to A^4 at which latter point it joins the Rutmoo River. The detail of construction of these drains will be entered into in its proper place; the general sketch above given will shew the advantages that have been taken of the successful operations in reducing the level of Spring water.

The whole of the Masonry works at the Rutmoo ~~River~~, with the exception of a portion of the Inlet, are founded upon Blocks undersunk from the lowest level to which the Spring water could be reduced. The maximum depth to which these

these blocks have been sunk below the level of the Dam flooring is 20 feet, and the order upon which the ~~Contractor~~ Engineer worked, was to the effect that the further sinking of a block was to cease immediately it came in contact with a well marked bed of clay below the depth of 12 feet from the Canal bed, the depth of 12 feet being considered a minimum.

In entering into a description of the detail and construction of these extensive works, I shall divide them into four items.

A The Revetments on the Curve of approach upon to the Dam and Inlet flanks, including the bridge of cross communication

B. The Dam with its Flanks

C. The Inlet with its Flanks

D. The Revetments on the Canal Channel on the down Stream side of the Dam and Inlet, including the Regulating Bridge and works attached to it.

A. This portion of the work consists of 2 lines of Revetment varying from 160 to 179 feet in distance from each other; the leading 250 feet in length which is in continuation of the alignment bearing on the Puttin Sunpassage, is 160 feet in width with the side revetments parallel to each other; the lower 550 feet with a bearing equally direct upon Roorkee is 179 feet in width with revetments also parallel; the intermediate space is occupied

=pied by Curves drawn on radii of 661·58 feet and 589·32 feet - meeting the two alignements above described in tangents at the tangential point with the lower alignement, is a bridge of cross communication across the Channel. The angle formed by the transition from the Puttee to the Roorkee alignement is, as I have before said equal to 117°. 11'. 10"

The Masonry blocks which form the foundations of the Revet= -ments and Bridge, are (excepting in those cases where a Stratum of clay has been met with) sunk to a depth of 20 feet. ~~The details of depths to which each separate block has been sunk will be seen by referring to the table and to the number of the block which corresponds with that in the Atlas~~

On the division of the work - which we are now describing, there are in the

			L.	B.
Right Revetment		71 Blocks	20'	x 12'
Left	do	62 do	20	x 12
Bridge	Bays	6 do	21	x 19½.
	Piers	2 do	25	x 17.
	Abutments	2 do	25	x 22½.

the dimensions shewing the measurement of the base, each block as it will be seen from the plans, being a truncated wedge the 2 ends being perpendicular and parallel to each other, the sides being inclined towards the top; each block rests on a curb or solid frame of Timber,

upon

upon which the Brick work was raised and allowed to indurate previously to the commencement of undersinking operations - On the completion of undersinking the interior hollows or wells were filled either with clay or sand, the latter being preferred, if available; in this State they were allowed to stand, as long a period as possible, so as to admit of settlement: the wells were then arched over, and the mass was ready to receive the superstructure - This plan of operations applies to all the blocks, each of which was subjected to the same process - On the lines of Revetment the space left between each pair of blocks (to prevent collision in sinking) was equal to ~~from 1½ to 2½~~ and that between the larger blocks, as in the Bridge was 2 feet This space is arched, and in some cases has been merely bricked over previously to the raising of the superstructure - Both in front and rear it is filled by piling driven to a depth of 20 ft, so as to expose as far as possible, ~~to loss~~ an unbroken face either to the action of the current in front, or to the thrust of the earth in the rear -

The Revetment walls both on the right and left, are on the same design, they offer a curved front to the Canal, and are strengthened by Counterforts ~~to the rear~~ - On the line connected with the underdrainage this wall is still further strengthened by the

Masonry

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Masonry Channels and Manholes, which are attached to them. At distances 60 feet apart from each other, and at a height of $10\frac{3}{4}$ feet from the Canal bed, rings, counters sunks in the face of the wall and held in position by strong iron rods which pass through it, are placed on the whole length of the Revetments for the convenience of boats and Rafts. On the left from the entrance into the masonry Channel in the upStream direction down to the Bridge, the height of the Revetments is $12\frac{1}{2}$ feet. below the Bridge it is $15\frac{1}{2}$ feet: a parapet wall $2\frac{1}{2}$ feet in height runs along the whole.

The Bridge consists of 3 bays of 35 feet each, each bay having a masonry flooring, and being 20 feet in height from the soffit of the crown of the arch to the flooring beneath it. the design of the Elevation is plain, and the roadway is 24 feet above the bed of the Canal. Flights of steps for the convenience of access to the water from the upper levels, have been built on both sides of the Canal in immediate contact with, and on both the up and downstream sides of the bridge.

The foundations of the Revetments and flooring of the Bridge, are protected by lines of Sheet piling, driven at a distance of 10 feet from the foot of the Masonry, the space between the piling and the masonry is filled with boulders or river stone to a depth of 5 feet, and the

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Revetment where the pressure of the earth acts in thrust on a concave surface, these bars are carried back to a distance of 20 & 25 feet and are anchored in the soil by Shams (tools used in well sinking) which on the termination of the Clear sinking were no longer required. The plan of this arrangement which was designed for the purpose of giving additional strength to the Revetment is shown in Plate XXV Sheet 5. Figs 1 and 2.

the whole is covered by sleepers or rafters of wood, for the purpose of retaining the Material in position, Advantage has been taken of the peculiar construction of the foundations, and their consisting of separate masses, to add still further to the strengthening of this open work by keying the front piling to the rear of the blocks by woodwork as shewn in Figs: 1 & 2 Plate XXX Sheet No 5

By referring to the position in which these curved lines of Revetment are built, and by considering the nature of the soil and the State of the Springs in the land through which the excavation was carried (vide Diagram CLXVI) it will be understood that the Canal Channel which runs transversely to the direction of the Spring Current has its right revetment opposed to it, in all its activity, whilst the left, which is cut off by the intervention of the Channel, is in a great measure relieved from its influence. It was for the purpose of remedying this defect that the Masonry drain the direction of which is shewn by the dotted lines and letters A^1 A^2 A^3 and A^4 in Diagram LXXIV, was designed; this drain which is 2½ feet in width commences at the point marked A^1, is carried on a rapid slope along the foot and at the rear of the Right Revetment until it meets the Bridge at the letter A^2; the drain then passes under the Bridge floorings to the opposite side of the

the Canal, and at the letter A³
turns to the right pursuing its
course along the foot of the left
Revetment, and escaping at the
point marked A⁴ into the bed
of the Rutmoo, by an open Sluice
connected with the tail floorings
of the Dam. The Section of this
drain is sufficient for the pur-
=poses of silt clearance, and at
every 60 feet in length, or inter-
=mediately between each Coun-
=terfort, a well or man hole is
constructed from the upper levels
and continued perpendicularly
through the arch of the Channel
not only for facilitating the clear-
=ance out of the Channel itself,
but for affording free ventilation.
On the passage of the Drain Chan-
=nel under the Bridge, similar
Cylinders or man holes are car-
=ried vertically through the
piers and abutments, and are
provided with lateral ventilation,
the upper orifice being closed
by a Stone Slab, for the purpose
of completing the Bridge road-
=way. The Great object of this
drain is to relieve the right
Revetment from the action of
the Springs, of that especially
which exerts a downward pres-
=sure upon the Masonry, and
which on the Mountain, or
right side of the Canal, is more
conspicuous than elsewhere.
Although the Plan and Section
of this drain as connected with
the Revetments are drawn in
Plate XXV of the Atlas, it will
be convenient for the purposes
of

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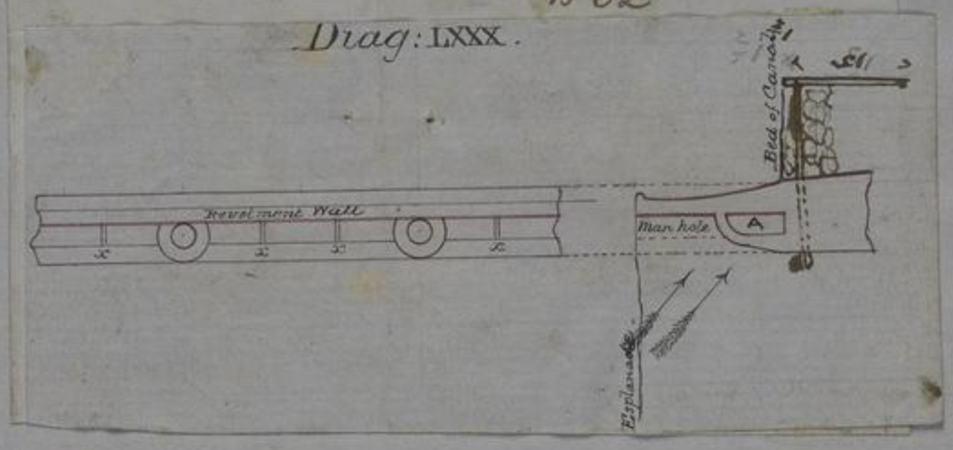
of explanation to introduce them in Diagram

Or 2600
B 62

Diag: LXXX.



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Sqr ¶ Cut

X. X X are slits through the arch and wall of the foot channel or drain A as in section. These slits are not more than ¼ or ½ an Inch in width, and they are covered in the rear with pieces of broken brick and loose rubble through which the Spring water can freely percolate, and at the same time offer as great an impediment as possible to the admission of silt: the rear of the wall is then filled in to the height of the Esplanade with Soil. By any person acquainted with agricultural drainage as it is practised in many English Counties, the design will be recognized, as a mere modification of the rudest Species of under drain Channel, where after excavating a ditch, the lower part of it is filled with broken Stone in angular fragments, over which the earth is thrown; the under drainage being effected by percolation through the Stony Stratum - I presume that, after a time, this Species of drainage becomes interrupted by deposits of impervious matter, which by

occupying

occupying the open spaces between the angular masses, checks and ultimately stops the passage of water, and that the only remedy is a periodical relief by either cleaning or renewing the frag-ments: an operation in the case of land drainage I should imagine leading to great trouble and expend-ture in that of

~~Works~~ the Antmoo Revetments of comparatively minor imp-portance from the modified form in which it has been prac-tised.

In laying out the line of drain underneath the bridge or that part of it which lies be-tween A² and A° - it was found necessary to deviate from the direct alignement on which it was originally designed; the change from a direct to a tortuous course is by no means an improvement either to the free passage of the water, or to facilitating clearance from silt

In conclusion I may observe that judging from the perpetual discharge of water from the escape opening at A⁴, and the constant gurgling of running water as heard through the man holes, on the whole length of the Re-vetments to which the Chan-nel is attached, the drain is acting very efficiently.

B - This includes the Dam proper, or the work for relieving the Canal Channel during the trains from the Torrent, which gains

admission

admission through the Inlet, it also acts at other periods of the year as a regulator to the Canal supply.

The work under the Division to which I have confined myself in the present detail, consists of a Platform carried across the bed of the Rutmoo River, protected on each flank, by Revetments which are in continuation of those described under the head of A.—

This work is built upon blocks of the same pattern as those before discribed, viz truncated wedges, whose ends are parallel, and whose sides slope inward to the top

				area of base
The platform rests upon	25	Blocks		30' x 30'
Upstream right wing	2	as	$\frac{20\cdot1+15}{2}$	x 12·6'
D. left wing	4	as	$\frac{13\cdot4+7\cdot0}{2}$	x 12·85'
Downstream right wing	2	as	19'	x 12'
D. left wing	5	as	19'	x 12'

their construction will be understood by reference to the Atlas; the details of adapting them to the superstructure are exactly the same as those before described for the Revetments. It will be observed however that additional width of platform both to the front and rear has been obtained by corbels and projections, so as to increase the width from 24 to 27 feet: the detail of which is given in the plan

The superstructure of the upstream wings and flanks of the Dam, corresponds with that of the Revetments of which they are in continuation, they are raised 13 feet above the flooring of the Dam, independently of the parapets

-pkts- The flanks are pierced by a passage constructed in the form of an inclined plane on a slope of 1 in 5 which gives the means of approach to the Dam from the Esplanade levels. The downstream or tailwings are built with an inclination towards the axis of the bed of the River; Their Superstructure which is 6 feet in height from the flooring of the Dam is connected with the flanks, and the Esplanade level by a series of steps.—

The Dam itself consists of 47 Sluices of 10 feet in width with their sills flush with the Canal bed, separated by piers of 3½ feet; the above are flanked on each side by 5 Sluices of the same width, but having their sills raised to a height of 6 feet, with intermediate piers of the same dimensions as those in the centre sluices. On the Extreme flanks are platforms raised to a height of 10 feet above the Canal bed, and corresponding in height with the rest of the piers. these elevated platforms which are 17 feet in length, are connected with the Revetment Esplanade by the inclined planes which I have before described as carried through the flanks of the Dam.

The Amount of Waterway therefore through the Sluices up to a height of 6 feet is equal to 470 feet in width: to a height of from 6 to 10 feet it is increased to 570 feet, and when flood water

rises

above that height, the water passes over the full expanse of the Masonry which is equal in width to 800 feet.—

For the 10 Sluices on the flanks the closing and opening will be left entirely to sleepers planks for which grooves are fitted to the piers. For the centre openings a form of double Sluice gate has been adopted, the plan of which will be understood by reference to Plate xxv of the Atlas A gate of 5 feet in height move-able on lower side pivots is placed on the rear of the Sluice Opening, this gate drops forward and towards the Canal stream and when it rests on the flooring is held in position by a bolt worked from the top of the pier: by re-moving the bolt, the gate is relieved from its prostrate position and is raised so as to admit of water to a depth of 5 feet passing down the Canal.- In front of this small gate is a large one equal in height to the pier itself moving also on lower side pivots and capable only of falling to the rear.—

The working of these double gates is as follows: when the Canal is full, the rear gate is held down on the floorings in the prostrate position above mentioned, by the bolt, and the large gate in the front is maintained in a vertical position so as to retain the Canal supply: On the occur-rence of a flood, these large gates are relieved, and are per-mitted to fall upon the floorings thereby

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thereby giving an open and uninterrupted passage for the water.

The floods having passed; the rear small gate is relieved by pulling up the bolt, and the gate is raised partly by its own specific gravity when it comes in contact with the Canal ~~Current~~ and partly by manual labor, and on its attaining a vertical position it is kept so by the front pressure of the water: the height of this gate being 5 feet an immediate supply can be admitted into the Canal equal to that extent; in the mean time the apparatus for raising the ~~front~~ gates is put in requisition, and ~~when these are raised to their full extent and fixed, the additional Canal supply which can then be admitted, rises over the front small gates, and the water by exerting an equal pressure on both their sides, admits of their being easily lowered, and~~ restored to and fixed in their recumbent position by the aforesaid bolts. When the Canal is in full supply, therefore, the smaller gate is out of use, its main object being to expedite the admission of water to a certain extent into the Canal: during the operation of raising the large gates.

The design is an ingenious one and is due to Mr Login, although its details have been worked out to completion by Captain Goodwyn, to whom the invention of the bolt for holding down the rear gate is due. The scheme has been experimented upon

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° This is considerably aided by the back water standing on the rear gates. The closing the larger or front gates, admits of the full supply being passed down the Canal. The small or rear gates are then dropped

upon, and the only difficulty that offered itself was in maintaining the small gate in a recumbent position, which its want of weight prevented when immersed in water. Captain Goodwyn's bolt appears to remedy this inconvenience, but it will require a good deal of practice before the working of the apparatus is satisfactorily developed, especially that part of it which is connected with the large gate, the weight of which is considerable. The details of the apparatus for raising the gates and keeping them in position are fully represented in plate XXV of the atlas.—

It must be understood that the Mountain Torrents with which the works are connected, carry in their waters material of all sorts, collected in their passage through extensive regions of forest; Trees of the largest size root and branch are frequently ~~strewn down~~ swept away, and carried with an overwhelming velocity along the course of the river. Grass, branches, and heavy timber left in the forests after the cutting season is passed, are swept away, and gathered in heaps on any obstruction that offers itself to the opposing current. The effect of the onward progress of this collected mass is to carry away the object that causes the obstruction with it; and to any work like a Dam with suspended self regulating

gates

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gates, or with attached and pro-
-jecting apparatus it would be
fatal. The great object, therefore,
with works of the sort which I
am now describing, is to adapt
the sluice gates in such a way
to the openings, that they may
be instantly removed, and self
placed in such a position that
they may offer no impediment
whatever to the current. The
gates which I have described,
fall, it will be observed, upon
the floorings, and the flood
passes over them. The whole
work is in fact, on the falling
of the gates, left perfectly naked,
without any further obstruction
to the passage of the water, than
that offered by the piers. —

The protective arangements
for covering the foot of the Revet-
-ments which I have before des-
-cribed ~~are~~ is continued round the
upstream flanks of the Dam,
along the face of which is a
similar line of apron, formed
by piling and box work filled
with boulders, the whole mass
being strongly held together by
sleepers; the apron which has
been thus described, has a slope
inwards towards the Canal
of 1½ feet, and it is intended
to act not only as a bar to the
interference of the water with
the foundations, but to protect
the wall from the effects of
the Current as it sweeps along
at its foot. —

On the down stream side
of

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of the Dam, a platform of box=
=work filled with river stone ex=
=tends to a width of 43½ feet from
the Masonry flooring, this is held
in position by double lines of
20 feet piling, strongly clamped
together by Sleepers fastened on
to the upper surface, the slope
of which is 2¼ feet on an in=
=cline down stream. To the whole
of these protective works the
greatest attention has been paid,
and as far as I can judge from
having seen them both in pro=
=gress, and after completion, they
appear to be excellent. The flanks
of the tail are protected by open
pile work driven in prolonga=
=tion of the down stream flank
walls.—

Water

C.— Embraces the Inlet
or platform which is built across
the Channel of the Rutmoo, &
parallel and opposite to the Dam
for the purpose of receiving the
floods into the Canal, as well
as for retaining the Canal supply
in its own channel; to this is
added flanking defences simi
=lar in many respects to those
attached to the Dam.—

The work is with the ex=
=ception of the greater portion of
the Inlet itself founded upon
blocks of the same pattern as
before, they come under the fol=
=lowing denomination.—

Platform of Inlet	3 Blocks	30'x 19'	in addition to plain foundation
Upstream Right wing	3 do	23'x 12'	
Do Do	1 do	17 x 12	
Do Left do	3 do	23 x 12'	
Do Do	1 do	17' x 12'	
Down Stream Right wing	2 do	$\frac{20{\cdot}1' + 15'}{2}$ x 12·6'	
Do Left do	4 do	$\frac{18{\cdot}4' + 7{\cdot}3}{2}$ x 12·85	

then construction will be under=stood by referring to the atlas; and the subordinate work ne=cessary for the reception of the superstructure is in every way similar to that before described.

The inlet is with the ex=ception of one block on the left and 2 on the right flank occu=pying a space of 94 feet in length, built on running lines of foundation wall, laid to a depth of 10 feet, or to the extreme depth to which the Spring water could be reduced. This was a very satisfactory result of ~~the~~ Logan's drainage operations, it led to great saving of expense, and to a more efficient found=ation; the running line of curtain wall being free from the interstices, which are an inevitable consequence of using blocks, and which by leading to leakage are ~~a~~ evils of no inconsiderable importance.

This ten feet foundation which is in the form of 2 parallel walls 3 feet thick and situated 13 feet apart, with cross walls of 3 feet in width at each 23 feet of its length, rests upon clay. It will be understood that the fact of there having been 3 blocks sunk was perfectly ac=cidental: these blocks would not have been introduced had Mr Logan been aware that he could obtain so great a depth as 10 feet by a reduction of the Spring level.—

The Superstructure of the downstream wings, or those on the

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the Canal side corresponds with the Revetments of which they are a continuation, their height is 15 feet, equal to that of the walls attached to the Dam - The flanks of the Inlet are also similar, having inclined planes on a slope of 1 in 5 for giving access to the Inlet platform from the higher levels of the Esplanade - The upstream wings, or those which flank the Torrent on its approach to the works, are placed in an oblique position inclining outwards from the axis of the River, they are 91 feet in length, and raised to a height corresponding with that of the Revetments. On the right the wing is pierced by two drain heads, each of which are 7 feet in width, and 5½ feet in height measuring from their floor to the Soffit of the Keystone. The Sill or flooring of these drains is on a level with that of the Inlet. To these drain heads, which are connected with the under Channels for relieving the country from inundation, clop gates and the necessary apparatus for opening and shutting them are attached: this apparatus in the shape of windlasses, Bitt heads &c is in the rear of the Revetment wall, and secured by its position from accident.

The Inlet consists of 29 Centre openings of 10 feet in width each, with their Sills raised 2 feet above the Canal bed, on each flank of these Centre

openings

openings are 14 of similar width,
the sides of which are raised 6
feet above the same level; the
extreme flanks are terminated
by a platform 17 feet in length
which is raised 10 feet above the
bed of the Canal, or equal in
elevation to ~~that of~~ the piers.
This flank platform is con-
-nected with the upper es-
-planade levels by an inclined
plane, ~~as before described~~ ~~made in a passage through~~
~~the Revetment.~~ The thickness
of the Piers is, as in the case of
those of the Dam 3½ feet, they
are fitted with vertical grooves
for the admission of sleeper planks,
bitt heads and the necessary ap-
-paratus required for the move
-ment of the Gates. The tops of
the piers have countersunk
rests cut into them in which
planks are laid from pier to
pier, so as to form a line of
communication across the
sluice openings; these are in
every respect similar to those
in the Dam.

The centre sluices have
gates moving on lower side pivots
which fall downstream to the
torrent, they are 8'. 8" in height
and constructed agreeably to
the detail shewn in the plan
It is supposed that the pres-
-sure of water running in the
Canal will with certain aid
from the bitt heads hold these
gates in position, leakage being
prevented by the usual simple
means adopted by the Native
Establishment of applying grass
whisps

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whisps of straw, &c. Counterpressure superior to that on the Canal side would necessarily force the gates open; and as flood water would ~~necessarily~~ glide this increased counterpressure, it would act of its own accord in relieving the sluices from the obstruction caused by the Gates. This species of gate applied as it is to the Rutmoo Inlet acts as a self regulator, and will, I doubt not, be found to be efficient - The 28 Side Openings or overfalls have no gates, they will be regulated by 4 planks of 12 Inches in depth each on the same plan as is practised on the Sunnee Canal works - These planks are raised at the ends by hooks run through an Iron Strap, which forms a loop at each extremity. It will be observed that none of the sleeper apparatus is required until the depth of water in the Canal exceeds 6 feet -

Before closing the account of the Dam and Inlet, which are the leading features of the works on the Rutmoo River, I must draw attention to the longitudinal profile as given in Diag: III Fig. 3, by this it will be seen that the effective Slope of the Torrent at the point where it is intersected by the Canal is equal to 8.23 feet per Mile or 1.87 Inches per 100 feet in length - Now looking transversely to the line passing through the Inlet, Canal Channel, and Dam; we find that the length occupied by these works is equal to 304.5 feet, or that

that the longitudinal axis of the Inlet is at a distance of 3045 feet from that of the outlet - with a slope, therefore, of 8·23 feet in the mile, the sill of the Inlet ought, that it may correspond with the slope of the bed of the River) to be 1·87" × 3·045 or 5·69 Inches above that of the outlet. There is an advantage, however, in maintaining the sill of the Inlet at a moderate height, as it enables us to reduce the extent of sluice area, and by so doing, to give us greater facilities for adapting the means of opening and shutting the gates; An increased velocity of current at this particular point so as to expedite the passage of silt and alluvial matter through the Canal Channel may possibly be an advantage; At any rate, but chiefly with reference to the respective slope above mentioned, and to the desire of reducing the height of the sluice openings; the sills of the Inlet are raised 24 Inches above the horizontal level: that of the Dam being flush with the above level, with the exception of a masonry step of 10 niches which the piers for the gate ~~sills for~~ require. - Dam by no means certain that it may not be found advisable hereafter to raise the sills of the Dam, by which two advantages will be gained; 1st a reduction to the dimensions of gate necessary for opening and shutting the sluice; 2nd a fixed Channel to a depth equal in amount to

that

that of the Sill level, in which a supply of water will pass down the Canal irrespective of sluices. At the Dhunowri works however, we have to observe the effects arising from two large volumes of water meeting at right angles in the centre of the confined area lying between the flanks of the Dams; that from the Torrent passing with a velocity due to a Slope of 8·23 feet per Mile, that from the Canal Channel which will include the drainage from all the Inlets below the Mysapoor Regulating Bridge (relieved only by the Kilkhal Escape and that attached to the Bahadoorabad Mill Channel) running with a velocity due merely to 1½ feet. I may observe that the anticipated consequences may be a retention on high levels of that volume which flows with the least velocity; in other words that the rapidly running Torrent which crosses the Canal Channel will retain in a measure the body of water that comes down the Canal; that this latter will find a vent, with considerable action on the works round the left flank of the Dam, with a proportionate regurgitation in the area lying on the opposite side of the Canal Channel and under the left Revetments of the Inlets. It is impossible to say to what extent this action of the waters may lead to the deposition of Silt, but in anticipating the action

action as certain in a greater or
less degree, I have strengthened
in every reasonable way the
foundations of the works at
the particular points referred
to, and I have raised the flank
Revetments to such a height, that
I believe they may be looked
upon as secure from any con-
=tingency of accident arising
from the meeting of the two
streams.

The whole of the works
attached to the Inlet and which
I have described under the
division C, are protected by
aprons ~~as before described~~ consist
=ing of piles driven 20 feet deep
in close lines at distances (as
represented in the plan) from the
foot of the walls in the case of
the Revetment, and in advance
of the front and rear in that
of the Inlet; the intermediate
space being filled with Box
work and River stone covered
with Sleepers well clamped
down to the piling. The aprons
on all occasions slope — out-
=wards from the work to a per-
=pendicular depth of 18 Inches.
The terminations of the wings
on the upstream side towards
the Torrent are well protected
by open piling connected by
transverse ties or transoms.—

D Under this letter we
arrive at the Regulating Bridge;
its connection with the Dam
and Inlet; and the uses made
of its foundations for the purposes
of under drainage.—

The

The whole of these works are founded on blocks which come under the following denomination

			area of base
Regulating Bridge		9	15 blocks 32 × 22
Do	Do	2	do 32 × 15
Upstream Right Revetment		4	do 18 × 12
D.	Left as	4	do 18 × 12
Downstream Right	do	2	do $\frac{28' + 15'2'}{2} \times 13'6'$
Do	Left do	2	do $\frac{28' + 15'2}{2} \times 13'6'$

the Method of adjusting the Sub-structure with reference to these blocks has been before described.

The superstructure of the upstream revetments which are the connecting walls between the flanks of the Dam and Inlet, and the upstream side of the Regulator, is similar to that on the down Stream side of the Bridge of cross communication which lies on the left of the Rutmoo River; it corresponds both in height and dimensions. On the down Stream side of the Regulating Bridge, the sides of the Canal Channel are protected by sweeping lines of Masonry wall enclosing flights of Steps or Ghats which give access to the Canal water from the berm. the height of these walls is equal to 12 feet they are in connection with the Bridge, and the sweep which is in immediate contact, is combined with a flight of steps ~~which~~ affords the means of approach to the Channel for under drainage from the levels of the berm.

With exception to the width of Roadway, which in the present case is only 22 feet, the

the Regulating bridge is precisely the same both in extent of waterway (viz: 10 bays of 20 feet in width each), and in apparatus for opening and closing, as that of the Miyapoor Regulator, a description, therefore, ~~from~~ details these becomes unnecessary. The Bridge wings, however, are adapted to the local requirements of the work, on the upper side they are of the usual dimensions; on the lower they are somewhat extended in length to meet an increased width of Embankment as well as a ramp which runs in continuation of the towing path from the Solani aqueduct Plate XXV of the Atlas exhibits this in its fullest detail.—

Under the head of C and when describing the right up stream wing Revetments, I drew attention to the Drain heads which are pierced through that part of the work, and to the Regulating arangments in the shape of Shutters &c that were connected with it. These drain heads are the openings for the admission of the Rutmoo stream, and for any water that may escape through the Inlet during the dry weather; they are in fact the openings by which it is hoped that we shall escape from inundation on that side of the Torent which is ~~on the up stream side of~~ above the works. The heads which I have before described as 7 feet in width each with a height from the floor to the

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the soffit of 5½ feet, are connected with arched passages which leave the Revetment at right angles to its face. These passages are separated by a pier 4 feet in width and they descend on a rapid slope of 9 feet in a length of 120·86 feet to a flooring situated, at the point of contact with the Abutment, at a depth of 7 feet below the level of the Canal bed. From this point the flooring is carried under that of the Bridge on a horizontal level until it terminates in the Excavated Channel. These passages meet the Bridge alignement by a curve tangential to the angle of approach; they leave the Bridge on a similar curve after passing under the Canal Channel and continue on a tangential line to a distance of 159 feet in which Space the Canal Embankments lying on the left are passed: ~~these subterranean passages~~ they then open out into the Channel excavated for the purpose of carrying off the water.

These underdrains are approached both on the up and down Stream sides of the bridge, by passages built in connection with the Revetments, access to the Channels themselves being gained by flights of steps. Man holes or cylindrical wells of 2 feet in diameter are carried perpendicularly through the piers and abutments, the tops of which ~~come in contact with~~ are in the bridge roadway, being covered by Stone Slabs; whilst Side Open-ings

a width of which is 20 feet, with slope of 3'44 feet per mile
3·44 feet per mile

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=ings give the means of ven=
=tilation. To each Pier and
Abutment 2 of these holes are
given, and it is supposed that
they, together with the flank
passages, will provide sufficient
means for clearing the Channels
from deposits. —

The plan for using these
Channels ought to be as follows:—
During floods their heads would
be entirely closed, the Shutters
would be down, and no access
to the flood water would be
permitted — It is only at periods
when the Rutmoo ~~was free~~ is not in
~~from~~ flood its Torrents that these drains
would be brought into use;
during this period, the Shutters
would be raised, and the
Mouths of the Channels would
be kept free and open. The
working parties of Beldars
attached to the Regulator, would
do all in their power to conduct
the Stream of the River (which
during the dry season is moder=
=ate) as well as water coming
from the works, to the Mouths
of the drain; rubbish in the
Shape of branches and trees
~~would~~ ought to be prevented from ap=
=proaching the Drain head
and it might be necesary
as a greater preventive to its
admission, to guard the open=
=ings by Iron gratings. —

It is indispensable that
during floods the drains should
be thrown out of use, otherwise
should no worse accident happen,
they

they will inevitably be chokes up. Whether it may be conve=nient at any time to attempt a scour, by forcing a current of considerable volume through these drains for the purpose of cleansing, may be left for after consideration; that they will require periodical clearances is certain, from the disposition of the slopes of the flooring, but it is hoped that whether by the means of access now given for the object of clearance, or whether by occasional scours of water passed off from the Canal, these Channels will be found capable of performing the duties for which they have been designed. I need hardly advert to the extraordinary value that the efficient main=tenance of these Channels as free water passages, possesses for benefitting the works at this par=ticular point, and the influence that it will have on the salubrity of the neighboring country. I have no hesitation in recording my opinion here, that the suc=cess which attended Mr Login's measures for drainage on these works, and which enabled me to carry out the design for the under channels which I have above described, is amongst all the extensive and difficult oprations which have ~~attended~~ characterized ~~upon~~ the execution of the Khadir works, that one of all others, which has given me the greatest

greatest satisfaction, and which has relieved me from one of the greatest difficulties.

Having thus described the whole of the works at the Rutmoo River, in a way which with the plans, I hope will be sufficiently clear, I will now give as con=cise an account as possible of the cost, material used in the construction, and the rates as charged by the Executive Engineer.—

I have before mentioned that the ground both with refer=ence to the works themselves and to the Brick fields in the neighborhood, was entirely laid out by Mr Logie, to whom as having to superintend the construction, free liberty was given to adapt them to his own conve=nience; the ground plan is shewn in Diagram LXXV; The Brickmaking was under Mr Firm, the Executive Officer of the Material Department

The sizes of brick used were 12" x 6" x 2½" and 9" x 4" x 3", the former being burned in the English, and the latter in the Native kilns: the latter I have before said were made in one of Sulls brick making machines

The whole of the Rutmoo works are built with Brick, with the exception of the massive parts of the foundations in which boulders brought from the passes in the Sebaliks are used. The heavy material placed in conjunction with the piling

and

and box work, for the protection of the works, was of River stone. The Lime was of the best description and similar to that used invariably in the Khadir works, made from Lime rock either burnt in the Deyra Valley, or from Lime boulders collected in the bed of the Ganges.—

The proportions of material use in Cement ~~was~~ were as follows

Mortar		1 Stone Lime 2 Sookri.
Plaster	Inlet and Dam Piers	1 Stone Lime 2 Sookri
	All the rest of the work	3 Stone Lime 2 Sookri.
		The whole being finished off with a Coley of 7 parts of Stone Lime to 1 of Sookri.

The total Amount of material is shewn in the following Table, to which is appended the rates of the different species of work which has been executed.—

Total Contents of Masonry	1496463			Cubic feet
Materials Expended				
Bricks — 12" × 6" × 2½	12134613			
— Do — English Machine	813852			
Boulders	126125			Maunds
Khama	20964			Cubic feet
Stone Lime	208981			Do
Sookee	397906			Do
Plain Masonry	16	13	-	Rs 100 Cub Ft
Brick on edge — do	20	9	5	Rs do
Arch — do	19	6	-	Rs do
Plastering	2	3	7	Rs 100 S Feet

The Grooves throughout the works at the Rutmoo have been protected by slips of Stone, and in all cases where the working of the gate or Sleeper apparatus was likely to injure the Masonry Stone has been used. The material is brought from the Quarries in the

the Agra District and is altogether of a Superior description to the Siwalik rock. In conclusion I may observe that the whole of the Brick work is stuccoed on its external surface, with a thin layer of lime Cement.

Previously to the rains of 1832 it was considered desirable to commence operations on the River, in progress towards its change of course upon the works. For this purpose 3 Cuts represented in the following dia-gram were made in prolongation and parallel to the axis of the works across a bend in the River.

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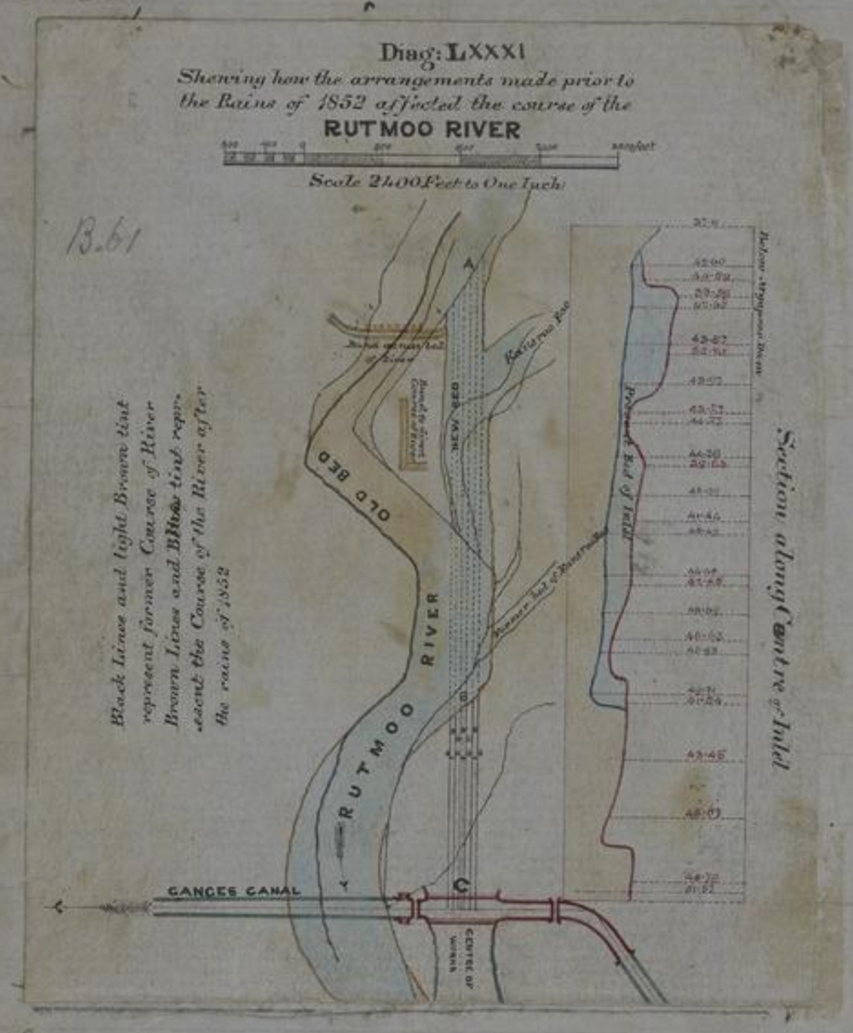
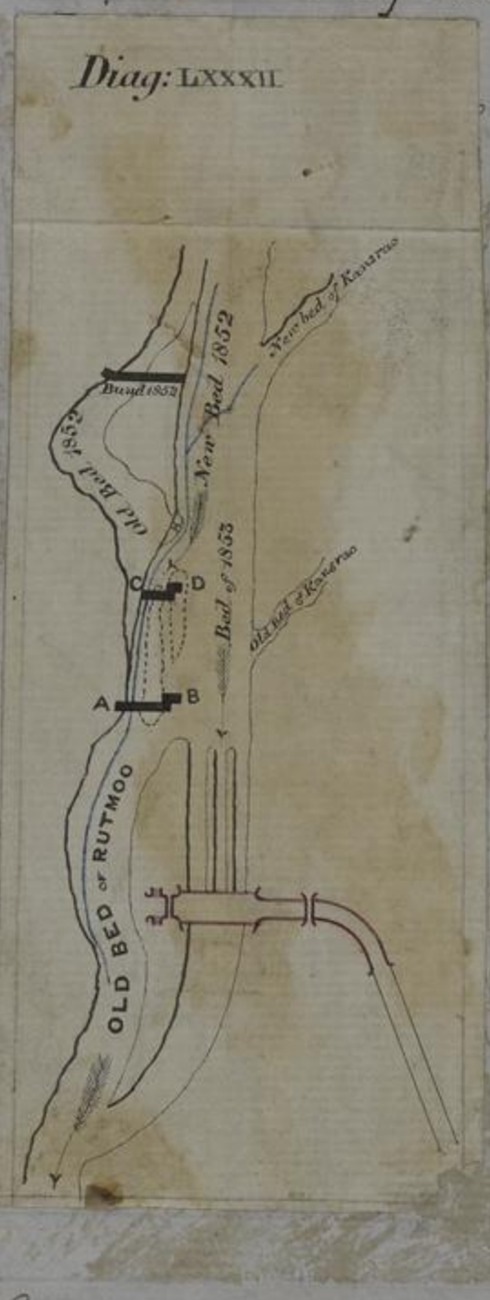


The effects after the rains of 1832 are shewn on the face of the dia-gram. ~~The Logics~~ The arrangements were well matured and so far as the straightening of the course of the River was attempted, they were successful. In 1833 and in preparation for the floods of that

that year, the Masonry works being sufficiently advanced to admit of water being passed over them the 3 Cuts above alluded to, were prolonged to the Inlet, or in the above Diagram from B to C. At the early part of the season there was some difficulty experienced in persuading the flood water to leave its old channel, and to follow the direct course which was opened out for it. This partly arose from the insufficiency of waterway at the heads of the newly excavated cuts at B, and partly from the natural tendency that the slopes of the bed gave the current towards its old direction. By opening out of the heads of these cuts, however, and by a judicious application of bunds and spurs, the River was ultimately conducted over the Masonry works, and placed in the new line upon which it will hereafter run. It has been before explained that for the maintenance of the Torrent in its direct course upon the works, as well as for other purposes in connection with deposits and the improvement of the low land lying above the Inlet, I proposed the application of parallel lines of bund or embankment across the valley situated at right angles to the Torrent itself, and constructed on the same design as that which had been adopted for similar purposes in the valley of the Puttri. — By combining with

with the temporary bund work necessary for the turning of the course of the River, the ends of two of the permanent parallel Embankments which were part of the original design, ~~the operations~~ appear to have been carried on ~~his operations~~ very successfully; and I cannot do better when stating the Success that attended upon these operations than ~~in~~ giving ~~Mr Logan's~~ the Engineer's own account of his progress. —

Diag LXXXII.



The above Diagram shews the State of the bed of the River in the Month of July 1853, at a period when the most active measures were being undertaken for turning the Course of the River over the works. At the points B C D there is high ground situated

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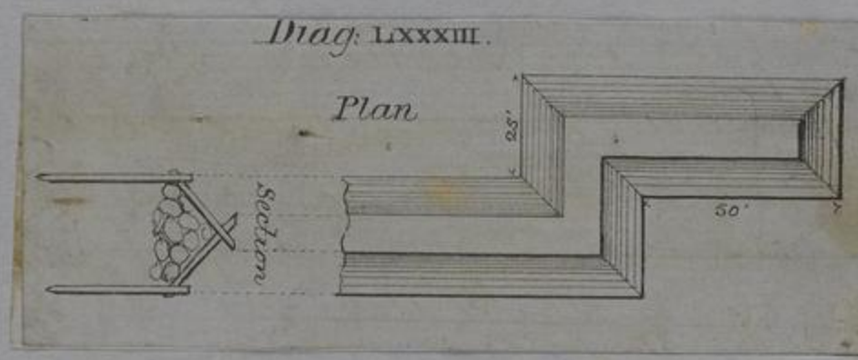
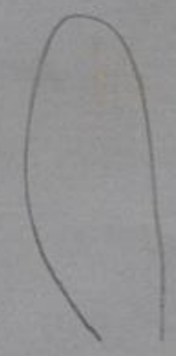
situated in the Centre of the bed of the River; at the highest point D Mr Login established the end of one of the permanent Embankments, similar to that at the Puttri and in shape and dimensions as follows:-

Diag. LXXXIII.

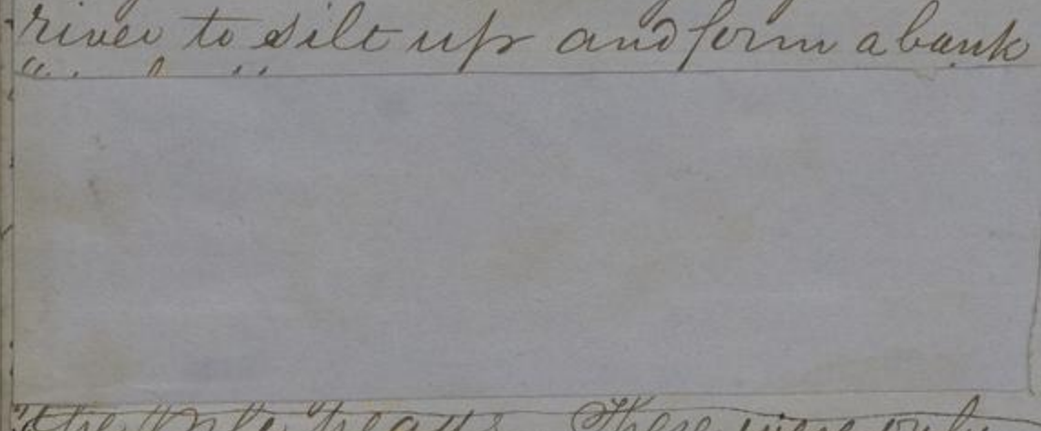


the triangular superstructure being made of kunies or rafters 15 feet in length, of which 3 pieces of material the piling and necessary protection were also made. The exposed or salient end X was left as open frame work for the water to break upon and the rest was filled with vitrified brick and masses of over burnt material brought from the brick fields. By the above arrangement the current was forced round the head of the Spur D and by meeting an impediment of the same sort at B, was urged into the head of the cuts which had been widened out to receive it. Mr Login in describing his disappointment in the failure of a Spur which was thrown out in the early part of the rains of 1853 at the point X, observes that "it struck me that were "I to use screw piles and to tie "branches of trees and jungle to their

"their heads, leaving the material
"to swing freely at a distance of
"25 feet or thereabouts on their
"down stream side (by which
"the piles would be protected from
"cutting immediately in their
"neighborhood) I might get the
"river to silt up and form a bank



at the spot in question — For
"purpose I procured some of the
"chains used in block sinking &
"fastened a quantity of jingles
"way above mentioned to



Diag. LXXXIII.

Disp of Cut

"the pile heads. There were only
"2 piles available 12 feet in length
"each, with screws 7 inches in
"diameter: these were screwed
"down into the bed of the river
"with their upper ring well
"below the surface; to these the
"material was chained. A few
"nights afterwards a small flood
"came down the River, and to my
"great astonishment when I visited
"the spot the morning afterwards
"I found that on each side of the
"piles sand equal in length
"to 300 feet on a breadth of 50,
"had deposited itself in the form
"of a bank nearly concealing
"from sight the whole of the jingle
"which had been attached to the
"pile heads. Seeing this" Mr Hogin
goes on to say," I immediately had
"a number of the screw piles
"made and instead of fix-
"ing the jingle by long de-
"tached chains I have put
"the piles in the following
"position, passing the chain
"through the rings at their
"heads, and securing the jingle

by

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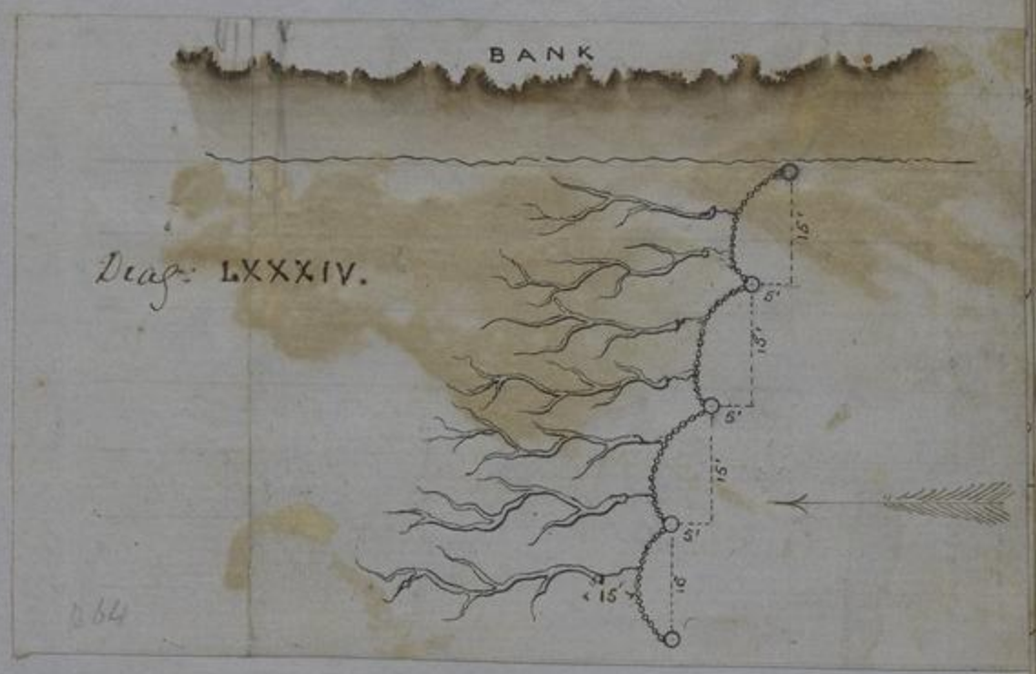
Size of Cut

"by rope".—

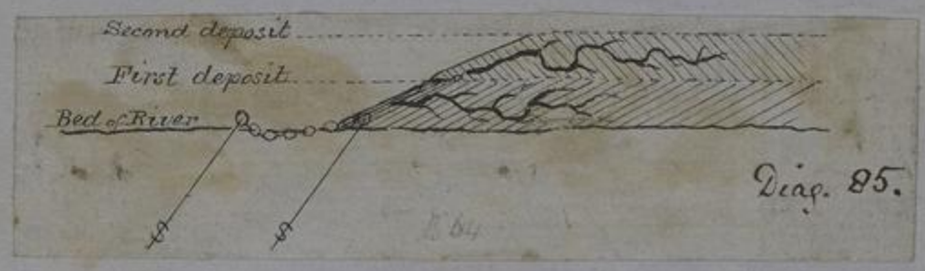


Diag: LXXXIV.

The object of substituting rope for chain was economy in saving the latter which became so deeply buried in sand that it was irrecoverable. ~~Mr Hogan~~ It was imagined that by additional layers of brushwood after each flood, ~~he may be able to raise~~ might be raised the sand bank to a height above the reach of floods, and by these means form a defensive work of much greater stability than that given by nature herself out of pure sand. ~~Mr Hogan explains his meaning~~ this is shown by the following diagram.—

Size of Cut

Note for Printer
The blank is intended for the "Second deposit" & "First deposit"



Diag. 85.

"By degrees" Mr Hogan says "I hope to have the bed raised "to the height of the natural "bank which borders the River "and by extending the use of "the Screw piles, to give the River "such an inclination to the "direct alignement upon the "Dam works, that there may be

"be no deviation from it hereafter"
The adaptation of the Screw pile (Mitchells) to the particular purpose to which it had in this case been applied is most undoubtedly a great accessory to our river works; it is in fact using the pile for mooring purposes for which it appears to me to be the most appropriate.

Drag

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II. The Works in the Ganges Khadir for the admission of Country Drainage

It will be understood from what has been written in previous Chapters, that the Canal, after it reaches the high land at Roorkee, proceeds on a course keeping as closely as possible to the Summit Levels of the country. Whether on its Main Trunk or on its branches, the direction pursues an uniform course between two Rivers, by the watershed of which it is entirely guided. The position of the Canal Channel is on the summit of a ridge which separates the drainage of its two boundary Rivers, above whose beds it is more or less elevated. The beds of the boundary rivers are naturally, as they ought to be artificially, the receptacles for flood drainage, and it has been a leading principle throughout the whole design, to protect the Canal Channel as much as possible from the Inlet of country

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country waters, and to throw the drainage away from the works, rather than to give it any encouragement to approach near them. In all cases where the irregularity of surface drainage, and the tortuous course of the natural watershed, have been intersected by the straight alignement of the Canal, & measures have either been taken or are to be taken for the effective relief of the flood water by cuts made into its neighbouring river. In no case ought this rule in my opinion to be deviated from; the beds of the natural rivers ought to be considered as the true Escapes, and the Canal Channel ought to be confined to its own especial duties. My views of the equilibrium that will be maintained in the surface waters by the connection of the main Canal and its branches with the subordinate lines of Rajbuhas have been fully entered into in the Chapter describing the Rajbuha's, and their double objects of Irrigation and safety valve. It is sufficient to advert here to the fact that during rain the amount of water collected by direct evidence, as well as that pouring into the Canal Channel through the bridge Inlets which from their position it may be noticed are capable of being entirely restricted to the Rajbuhas themselves; will add sufficiently to the supply of water passing down the Chan-

nel

-nel, even with the relief afforded by the Escapes, to render any superfluous inlet (especially where such is avoidable) unnecessary. —

The works that come under this section are distinctly inlets for the reception of flood water from extensive areas of country; they are directly connected with the excavated Channel, and they are confined entirely to the tract lying above Roorkee. With the exception of the Lounda Leniwala and Kunkhul drainage which however, is more connected with Shingle, than with sandy bedded rivers, the water which is admitted through these Inlets is that which falls upon wild and uncultivated surfaces lying at the foot of the Siwaliks, and it is free from the sand and silt which characterizes the ~~Mountain~~ Torrents ~~which take~~ whose heads ~~are within~~ ~~their beds lie~~ the mountains.

Of these works there are five - viz^a.

			width of waterway
1st	The Lounda Leniwala	Inlet	50 feet
2nd	" Kunkhul	do	30 feet
3rd	" Dowalapoor	do	100 feet
4th	" Selimpoor	do	150.
5th	" Badshahpoor	do	50.

With the exception of the work at Kunkhul which varies in some respects, the design of these inlets is uniform: it is a combination of Ghat, or stairs with a passage for the Inlet of floods the flight of steps being available for access to the Canal water for bathing

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bathing, or for other purposes.
The sill or upper step is in all
cases retained on a level either equal
to or above the maximum high
water mark in the Canal, and
the flood water on its admission
passes over the flight of steps,
and is retained within its limits
by flank walls.-

The local depression of
the Country at Kunkhul, at
the site where the Inlet is con-
-structed, rendered it necessary to
modify in a slight degree the
plan which has been elsewhere
adopted;- the modification will
be understood by referring to
plate XV. Sheet 3 of the Atlas; it consists
in a sluice fixed centrically in
the flight of steps, so as to admit
of the flood water of the Country
passing into the Canal at low
levels, when by the closing of
the Regulator at Myapoor, the
Channel is comparatively dry.
This sluice is fitted with vane
planks or sleepers, in the way
which is usually practised
elsewhere.-

These works are built al-
-most entirely with boulders
(River Stone) collected in the
bed of the Ganges and its branches,
they are faced with brick, and
the use of this material is ex-
-tended to all parts, where ex-
-ternal finish is required, or
where the application of lines
of brick masonry was considered
to give additional stability to
the Structure.- The outer surface
is stuccoed, and made of one
uniform

uniform appearance by a coating of plaster. The whole of these works are designed on a scale of Solidity, adapted to the rough work which they will have to undergo; they are strongly protected both on the upper and lower levels by piling and box work, and no means have been spared to render them as efficient as possible. —

It is unnecessary in this place to advert to the causes which led to the construction of these works as they have been freely entered into in a former Chapter, it may be sufficient here to repeat that they are confined entirely to the Regions connected with the mountains, and to parts of the country where the line of the Canal by running at right angles to the natural slope ~~of the country~~, intersects the drainage. The width of water way which has been given to each of the Inlets, will, it is believed, reduce the action of the current, and render its effects upon the works harmless; and considering them as Masonry Ghats for giving access to the water, their introduction at detached points will undoubtedly be of great convenience to the people in the neighbouring villages. —

The rates or cost of building will be shewn by the following Table

Sounda Levi Work Inbl. Masonry —	15	2	8	pr 100 Cubic
Kankhul — do —	13	12	8	pr do
Jowalapoor — do —	14	3	1	pr do
Sulempoor — do —	15	1	.	pr do
Baidshahpoor do —	14	3	..	pr do
	12 15½	2	2	9

The Cement which is used in the body of the work consists of

1 Part Stone Lime
1 " Sonkee

the Stucco or plaster of

2 Parts Kunno Lime
1 " Sonkee -

III. The Works in the Ganges Khadir for the Escape of Country Drainage. -

The works for this purpose are as it will be understood from the description before given, of an exceedingly limited nature; they are in fact confined to one Masonry outlet, and an arrangement, to which I have drawn attention, when describing the Selimpoor Inlet, for permitting flood water to pass over the Canal Channel through openings left in the embankments immediately opposite the inlets in question

In regard to the first which is situated on the left bank directly opposite the Kunkhul Inlet, its specific object is to dispose of the water received from that source without adding its quota to the sufficiently inconvenient supply which the want of Escapes on the line from Koya-poor to the Rutnoo River, ne-cess-

-cessarily collects in the Canal Channel. Its waterway is in 2 bays of 10 feet each giving a full escape of 20 feet, the Sill being on a level with the Canal bed, and the soffit of the Arches raised to a height of 11·34 feet above it. The openings are regulated by Sleeper planks worked in grooves. Independently of its use as an Escape for floods, this outlet acts as the head of a line of Irrigation that extends down the high land bounding on the right bank of the Ganges; it also provides a supply for Mile purposes

Boulders are used in the foundations and massive parts of the building, whilst brick masonry constitutes the superstructure; its Plan, Section &c, are shewn in plate XVI of the Atlas

The Total Quantity of material used, and the rates or cost of the building are shewn in the following Table.

Materials Expended					
Bricks 12"×6"×2½		45075			
Boulders		13361			Maunds
Stone Lime		4310			Cubic feet
Sookee		4220			a 8
Masonry	Rs	13	12	8	per 100 Cubfeet

The proportions of Material in the Cement is as follows:-

1 Part Stone Lime
1 " Sookee

Those of the Stucco, or Plaster are

2 Parts Stone Lime
1 " Sookee

7 2 4

The outlet was begun and completed by Mr Kay, the Assistant Engineer on these works, under the superviscion of Captain Goodwyn —

The Gaps or Openings which have been left through the Em=bankments opposite the Selma=pour Inlet are 300 feet in width; they are merely intended to act as Safety valves in the Event of extraordinarily high floods to which from the height of their Sill from the bed of the Canal Channel they are alone adapted; they are protected by piling and box work, and although it is possible that their aid may never be brought into requisition, they may in a case of exigency be the means of doing good service: it will be understood however that the benefit that arises from these escapes in re=lieving the main Channel from Excess of flood water, will although in a degree comparatively trifling, be negatived by their effect upon the Navigable Channel, which ~~would naturally~~ will be a sufferer in a greater or less degree: the alternative, however, is a convenient one, and as such may be considered as an useful appendage to the design —

Before closing the subject of Escapes, I may remark that the Navigable Channel itself as well as the Mill line offers in a small degree the means of relieving the Main Canal

under

under extraordinary pressures of water: it would not be advisable in ordinary cases to divert either the one or the other from the spe=cific uses for which they were intended; the same species of flood, however, that brought into use the escape afforded by the Gap in the Selimpoor Em=bankment, might render the others worthy of consideration; I mention them here as a species of 'pis aller' without the slight=est desire or wish of seeing the alternatives practised. —

IV. The Superpassages for carrying the Ranipoor and Puttri Torrents over the Canal. —

The term "Superpassage" has been applied to works on the Canals in these provinces, which convey drainage water over the Channels, by well protected and parapeted Ma=sonry passages. In contradis=tinction to Aqueducts which carry a perennial supply, and are built for the purposes of a regular flow of water, the Superpassage, merely acts as a water course during floods, and at other periods is subser=vient to all the purposes of cross communication. On a small scale works of this description are in common

use

use in the Deyra Doon, and on the
western Jumna Canals in the
neighborhood of the ridge of
low mountains through which
the Canal Channel is carried on
its approach to the City of Delhi,
there were until lately numerous
works of this sort, acting in the
double capacity of bridges during
the dry season, and passages
for the flood water from the
mountains during the rains.

The causes which led to
the adoption of this species of
work on the Ganges Canal, have
been fully explained in Chapter
II Part II of this history, and the
necessity for this adoption even
under the great difficulties and
greater expense, which it entailed
upon the Estimates, has been so
fully described, that I shall con-
=fine myself in this place to
details of design and construction
and to the extent and character
of the catchment basins which
are dependent upon the Super-
=passages for their thorough drain
=age.

The works which come
under the above denomination
are confined to the Khalls, and
they have been constructed Spe-
=cifically for the passage of the
Ramipoor and Puttri Torents.
The Catchment basins or area
confined within the limits of
the watershed of these lines of
drainage may be considered
as 45 and 80 Square Miles
respectively — That of the Rami
=poor torrent averages in width

4½

Plan

P. W. P. 65. Vol II Ch. 1

4½, and has a total length of 10 miles.
That of the Puttri is 5 miles in
width with an average length of
16. From the exceedingly intricate
lining out of the Ravines and
Valleys in the Sewaliks, it is quite
impracticable to determine with
any precision the true and accurate
line of watershed, the diagram
however, which is appended to the
Chapter above alluded to, exhibits
for all practical purposes an out-
-line of these limits sufficiently
correct, to enable us to estimate
with tolerable certainty the value
of the enclosed area.-

The Catchment basins of both
the Torents with which we are now
dealing, consist of long strips of
land, the lower extremities of
which terminate on the Supe-
-passages. The Northern portion
of these strips, or that which is
farthest distant from the Canal
is occupied entirely by mountains
the highest points of which rise
to a height of from 800 to 1000 feet
above the Country on which the
Canal is situated. In both the
basins of the Randpoor and
Puttri atleast one half of their
area is thus occupied, the remain-
-ing half, being on a rapid slope
towards the direction of the Canal
and having its surface covered
with either grass or low Forest
trees, to which the cultivated land
and villages bear a very small
proportion.- The Hills themselves
consist of upheaved alluvium,
strata of clay, sand and boulders
lying at an angle of about

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20 degrees; this angle with the ex-
=ception of that portion of the
Sewaliks which is in contact
with Rundwar and the Ganges
dips S.Eselieue, universally to the
Northast shewing its scarp to the
plains; immediately at Rundwar
however, the direction of this dip
is reversed, the inclination of the
Strata being to the South west.
These hills are subject to constant
degradation; every rainy season
precipitates masses broken off
from cliffs into the beds of the
Torients, by the aid of which the
detritus is carried forward and
spread over the plains lying at
their foot.. These plains, which
as I have before said, are on a
rapid although gradually de-
=creasing slope in the direction
of the Canal, consist entirely of
the material thus brought down
from the mountains, deposited
according to its gravity, Boulders
and shingle forming the slopes
of the upper whilst sand is
the prevailing ingredient of the
lower regions. It is in this sand
that the Ganges Canal has been
excavated, and it is in soil
more or less of a Sandy nature
that the works I am now about

describe have been built-
=ing the works in their order
precedence those connected

with the Rampoor Torrent will
first come under review.

The Rampoor Superpassage and Works connected with

with it —

At the point where this work is constructed, and previously to the Project of 1850, a Masonry perpendicular drop Inlet for the admission of the Torrent, and an outlet for its Escape — — — — — — had been built; The former on the right, the latter on the left of the Canal Channel.. The existence of these works, therefore, placed a limit in an economical point of view on the new design, it being desirable to adapt as far as it was possible, the foundations and superstructure of the old to the new work. The demands for the passage of the Canal Water were an Open Channel of 200 feet in width, a Lock Channel of 16, and a Mill race of 10: It was essential that the flood water of the Ranipoor Torrent should pass over the whole of these Channels without any sort of interference. The transverse section of the Canal across the Old Masonry works is shewn in the following diagram

Sign of Cut

Maintaining the face of the perpendicular of the Inlet A B as the alignement of the right flank

Tank of the proposed new build-ing, the Space to work upon was equal to 24'.. 6" + 24'.. 4½" or a clear 27'.. 10½". The disposition of the required Channels to meet the above width was arranged as follows:- commencing from the left of the above diagram..

	Feet	Inches
Abutment of Mill Channel	4	2½
Mill Channel	10	"
Pier	4	"
Lock Channel	19	"
8 Piers 4'.. 4" each	32	8
8 Waterways of main Channel	200	"
Total width	271	10½

It will be observed that the first three items of the above Table occupy a Space of 18'.. 2½" only, whereas the Escape Platform was 24'.. 4½" - it became necessary therefore, to cut away 6 ft 2 inches of the front for the purpose of the Lock Chamber; with the exception of this, and the removal of the wings and a portion of the Reservoir of the Inlet, the whole of the buildings which were formerly constructed were brought into use as abutments for the new work, into which they were built without any further Modification: this will be understood by referring to Plate XIX of the Atlas, which exhibits the plan of this work in all its details.

I have in the Chapter on Navigation Cuts, explained the Method by which the Navigable Canal and the Mill Channel reach the passages respectively appropriated to their uses; and shewn how by means of a revet-ment

=ment of a line of Separation has been drawn between them and the body of water in the main Channel; it remains, therefore, in completing the description of this work, to note that the water=ways eight in number for the passage of the main Stream of the Canal, are equal to that of the Falls or Masonry Descents, the piers having additional Solidity to correspond with the uses to w^h^ which the building is to be applied. The water passes over an ogee descent with a drop of 9 feet, and falls into Chambers of an equal length with that of the Superstructure. This Superstructure which rests on the pier heads, and is formed of floor=ings built upon Segmental arches with 60° radius, is in total width equal to 210 feet, of which 7 feet on each side are appropriated to parapets, and the remaining 196 to the water way for the floods. As in the case of the Masonry falls the upper levels of the ogees are fitted with grooves and Sleepers for the purpose of closing the Chambers, a convenience that is obtained by projecting the pier in the form of a Cut water to the front alignement of the work. The foundations of the upper and lower levels are protected by lines of piling and box work the former on a width of 10 feet the latter on a width of 70 feet. the Revetments also on the Right and left are similarly protected, and much attention has been given to securing the Masonry foundations which are connected with

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rain Canal Channel
- These protective ex-
consist of loose boulders
sition by woodwork,
they will require constant watch
-ing, and repair, and the Canal
ought never to be laid dry, with
=out an anxious inspection
being given not only to these par
-ticular protective works, but to
all those which are similarly
situated -

The upper flooring or those
of the Superpassage itself are
in their thinnest measurement
(that is to say over the Crown of
the Arches) equal to 3 feet - The
parapets on the right and left
are in width 7 and in height 14
feet; they are continued inland from
~~projected beyond~~ the
body of the work to a distance
of 100 feet on each side, expanding outwardly
so as to form wings for keeping
the water within bounds on its
ingress to and egress from the Super
-passage -

The plan which has been
adopted for giving protection to
the Masonry work, both floorings
and flanks, and of delivering the
torrent upon the Superpassage
Channel, is shewn in Plate XIX
of the Atlas - The great object has
been to bring the Torrent upon
the work by a gradual process,
and to avoid as much as possi
=ble abrupt contact; to give the
Current a bearing upon the axis
of the passage, and to prevent
as much as possible any tend
=ency to lateral action - The
works at the Puttri exhibit the
plans that have been adopted
for

3 feet thick Arch 2½
Floors ½
Total 3 feet

for these purposes, on a more ex-
tended scale than those which
I am now describing, which are,
however, equally well adapted for
the especial locality. The general
design of the Spurs and Embank-
ments is that which from long
practical experience in Northern
Italy, has been considered the best
and most efficient. The principle
upon which they have been laid
out, is, as far as local circumstances
would permit, similar; and as
I have had ocular demonstration
of the good effects not only of the
design of Embankment, but of
the plan which is usually adopted
in its disposition, by inspecting
the courses of Rivers which have
been turned under the discipline
of the above works, I have adopted
them without hesitation, and
doubtless with certain modifica-
tions dependent on material
and the character of the Rivers
which we have to deal with
(which I may observe in passing
are in the early part of their course
similar in every respect to those
of Lombardy and Piedmont)
they will be as applicable to
India as to Italy. At any rate
centuries of experience gained
in Europe, may very fairly be
taken advantage of, and as it is
as well to start from the point
to which improvement has arrived,
instead of persisting in experi-
ments which in all probability
have years ago proved unsatisfactory
~~been regarded by unsatisfactory results~~; it
is wise to adopt those measures
which bear the guarantee of

successful

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successful experience. I have not been backward, therefore, in adopting as models those works in Lombardy and Piedmont, which I was satisfied both from observations and from the fact of their practical benefit, would be valuable accessories to our works in Northern India.

The plan which I have put in practice in conducting the Torent and its flood waters upon the entrance of the Superpassage is shewn in Plate XXIV. Sheet 5 of the Atlas, which representing the Works on the Puttri, serves as a pattern for those on the Valley of the Ranipoor. It consists of a series of parallel embankments described at right angles to the axis of the Superpassage. These Embankments which are made of earth oppose a salient and well protected end to the current. An open passage of considerable dimensions, but which decreases in width to that of the Masonry Channel, is flanked on each side by the salient ends above referred to, the form of which is adapted to restrain the action of the current, to secure back water on the upstream faces of the embankments, and ultimately deposits of sand along the whole line of the valley. This open funnel shaped passage delivers the water upon a strongly built and well protected series of works more immediately connected with the Masonry superpassage, and devised for the purpose of easing off the action of the water on its coming in

Contact

contact with the Masonry - The
series of works above alluded to,
consist of flank defences and
Spurs made of boulders and
heavy material strongly tied
together by wooden framework,
their fronts being covered by
aprons of similar material guarded
by lines of piles driven to a depth
of from 16 to 20 feet. The ingress
front of the Superpassage itself
is covered by an apron of frame
box work, with an upper flooring
of Rubble masonry, the apron ~~itself~~
has an inclination of 5 feet
sloping from the level of the floor
of the Superpassage Channel,
back in the up Stream direction.
The width of this apron is 100
feet, it is carried in a circular
sweep so as to cover the flanks,
and the utmost care has been
given, by placing these protective
works at the lowest possible level,
and by guarding them by lines
of piles driven as deeply and as
closely together as ~~it~~ was possible,
to place them out of the reach
of the whirlpools and regurgitations
of water which may be anticipated during floods.

At the point where the
water will leave the channel of
the Superpassage, the works are
of a less complicated nature,
Here, however, the defences on the
flanks, and the apron attached
to the flooring are built of the
same material, and much on
the same plan as those on the
upstream face; the object at this
point, however, is to get rid of
the water, after it has passed
through the contracted Channel

of

of the superpassages with the least interference to its onward progress; the side defences therefore, are merely bunds carried on in prolongation of the masonry wings of the work to a sufficient distance, to deliver the water upon the surface of the country, and the apron is intended to protect the downstream side of the building from the action of the water in excavating holes on its escape from the floorings -

The connecting link between the wings and the outward defences is formed by a circular mass of stone and frame work, in which the terminating point of the wing wall is strongly imbedded.

In the above description I have given a general outline of the works which have been adopted for both the Puttri and the Ramipur superpassages for delivering the Torents upon their channels; the extents to which they have been carried in each will be seen by reference to the plans. At the latter, although the defences in immediate connection with the superpassage are precisely of the same order as those at the Puttri, those at a distance are comparatively small; a circumstance arising from local causes, and from the peculiarities of the Torents themselves -

It will be understood by referring to the 2nd Chapter of the 2nd part, in which I expressed my views as to the effects upon the beds of Sandy Torents by the interposition of bars

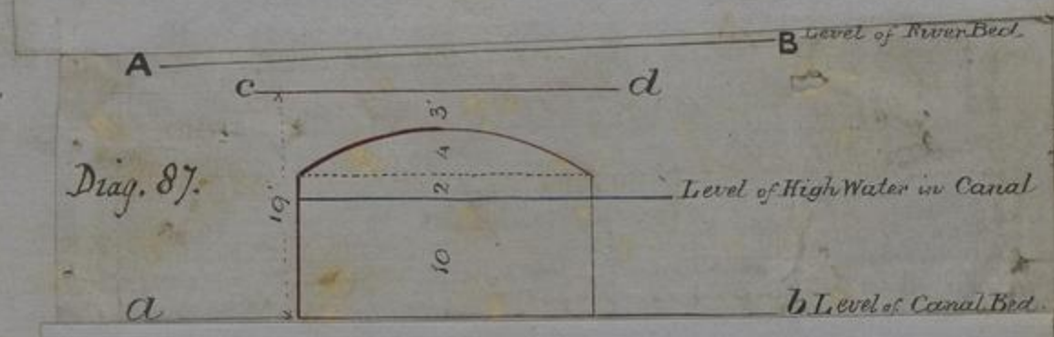
bars of masonry; that my great object in designing the works which we are now describing was to depress the flooring of the superpassage to its lowest possible limits, so that its surface should be below the "line of the supposed limit "to the action of the Torrent".

There were two fixed levels to work upon; viz^t. the surface level of the Country as in the case of the Puttri (or of the Torrent as in that of the Ramipoor) and the true level of the Canal bed: be-=tween these lines the parts of the design were necessarily restricted. I had to provide for a passage for boats along the navigable line, with a maximum height of water equal to 10 feet; and I had to give a sufficient thickness of arch and flooring for the pur-=poses of the passage of the Tor-=rent across the Canal, for this I considered 3 feet was the mini-=mum that could be fairly & given. I had also to provide & against the contingency of floods coming down the Canal by giving sufficient Outerway for their reception. Whatever there-=fore the distance might be between the above two levels, I had a fixed quantity to work upon viz^t.—

10 feet Depth of water
3 feet Thickness of Masonry for arch and flooring
6 feet For Headway for the passage of boats and for Contingencies of Canal floods.—

giving a total of 19 feet in depth. The following Diagram will still further explain my meanings

meaning.—



Diag. 87.

Section of Cut

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unless it might be considered that 6 feet was an unnecessary height for headway, the 19 feet above shewn was an indispensable and fixed measurement by which I was limited.—

In the case of the Ramipoor Superpassage which was built on the site of the natural Torent, it so happens that the lines A B and a b are separated by a depth of 22·445 feet, so that the flooring c d of the superpassage is 3·445 below the true bed of the Torent, I consider this to be a very favourable occurrence, although during the period that we have had the River under our registers, the fluctuations in the height of the bed have been so great, that it is not clear to me what may be the result on the Superpassage itself coming into operation. At any rate the floods will reach the passage in the first instance on a sandy bed, 3·445 feet of which it will have to clear away, before it touches the masonry flooring. The Puttri work is not so favourably situated in this respect, but I shall reserve my remarks on that until hereafter.—

I may as well, however, observe that by the restrictions placed on the height of the superpassage works from the bed of the Canal

and

and more especially from the circumstance of the Dock Channel being on the left, or on the down stream end of the Superpassage. I have retained the floorings on a horizontal level. It is clear that a slope could only have been given by raising the masonry of the upstream end, in proportion to the declivity required to make it in accordance with the slope of the country. In the case of the Puttri the rise would have been 1·34 feet, and in that of the Ramipoor 9·07 inches; the former having an effective slope of 25·13 feet per mile, and the latter a slope of 14·11 feet the lengths of superpassage channel being in the first case 283 and in the latter 282'. 10½". Now as it is perfectly clear that this slope may as well be established by the River itself, and formed of its own material, as built of rigid masonry, I saw no necessity for deserting the horizontal line, but satisfied myself by raising the parapets to a sufficient height to give full scope for any elevation or fall that might be due to the natural slope desired by the River.

The Ramipoor Superpassage and masonry works attached are, with the exception of the massive parts of the foundations floorings and Spandrils, which are built with boulders brought from the bed of the Ganges River, constructed entirely of brick masonry. The whole work was laid out and its progress was carefully superintended by Mr Kay, the Assistant Engineer, under

Mr Ross

whose care all the buildings in the neighborhood have been executed

The bricks 12"×6"×2½", were burnt in the manufactories at the village of Selimpoor, in the same species of kiln as has been used at Roorkee, they are of the best description procurable from the soil in the neighborhood

The Quantity of material which was expended on the Ramipoor Surpi passage is as follows:—

Bricks	12"×6"×2½"	6213753	
— Do	12"×6"×2"	1500	
Boulders		1467814	Rounds Cubfeet
Stone Lime		300294	— —
Sookee		298395	— —

The Cement is composed of the following ingredients

1 Part Stone Lime
1 — Sookee —

with the most abundant use of water

The rates at which the work was executed are shewn in the following Table.—

Total Contents of Masonry 1636252 Cubfeet

Arch Masonry —	23	.	3	pr 100 Cubfeet
Brick on Edge — do —	15	lbs	4	pr do
Plain — do —	15	11	..	pr do
Boulder — do —	10	8	10	pr do
Plaster	5	8	3	pr 100 Spfeet

The Table ~~here~~ given below shews the description of soil that was met with in the excavations for the Ramipoor Works. The boring rod shewed no signs of water at a depth of 40 feet at

At the Moongawalla well at a distance of 2650 feet to the westward Spring water is at a depth of 60 feet from the surface.—

Nos.	Kinds of Earth	Depth of each Strata from the Canal bed to bottom of Foundn.	
		Ft	Ins.
1	Brown Sand	3	3
2	Sandy Clay	6	..
3	Brown Sand	1	6
4	Do	1	4
5	Fine Gravel	..	9
6	Brown Sand	1	2
7	Brown Clay	..	6
8	Grey Sand	1	9
9	Grey Sand	1	9
10	Brown Sand	2	..
2	6	15	7½
Total depth of Foundations		20	..

Remarks

Containing about 10 per Cent of Clay

a Combination of about 70 per Cent of Fine Sand with 30 of Clay—

Containing a slight mixture of Sedimentary deposits

Fine quality

Containing abt 40 per Cent of Sand

Fine quality

containing about 20 per Cent of fine Sand

Good for building purposes

Fine quality

—do—

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I have before described the Catchment basin of the Ramipoor Torrent, or that part of it at least which lies on the upstream side of the Canal, as equal in area to 45 Square Miles, One half of which consists of Mountain, and the other half of open Forest country, the latter on a very rapid slope towards the Canal. A map of the Country lying between the foot of the Hills and the Canal, with its Surface marked by the figures denoting the relative levels, with reference to the flooring of the Regulating Bridge at Ryapoor, (the Zero from which all the Canal levels are counted) will be found at Plate III. of the Atlas.—

The quantity of rain water that would fall upon a Surface equal to 45 Square Miles, allowing 12 Inches in perpendicular depths

depth during 24 hours, would be equal to 14520 Cubic feet per Second an amount that may be considered a maximum on an extended area. The value of the Channel of the Superpassage to meet the discharge may be estimated by the following Table.—

D	R	Velocity V	Velocity u	Velocity U	Area	Discharge per Second
1	11·879	5·127	7·546	2·708	196·167	1005·748
2	23·520	7·279	10·188	4·370	392·334	2855·799
3	34·932	8·907	12·137	5·677	588·501	5241·778
4	46·119	10·258	13·730	6·786	784·668	8049·128
5	57·098	11·431	15·104	7·758	980·835	11211·925
6	67·849	12·475	16·315	8·635	1177·002	14683·100
7	78·404	13·423	17·410	9·436	1373·169	18432·047
8	88·760	14·292	18·410	10·174	1569·336	22429·136
9	98·923	15·097	19·331	10·853	1765·503	26653·789
10	108·897	15·869	20·212	11·526	1961·670	31129·741

where the 1st Column gives the depth of the water passing through the Channel, with the discharge of Cubic feet per Second, and its attendant velocities in parallel columns

Agreeably to the above Table a depth of water on the Channel equal to Six feet, would in One Second carry off the water that would fall in that space of time

By reference to the following Section which shews the true slope of the torrent on its approach and departure from the floorings of the Superpassage it will be seen that the former, AB, is on an average of 15·88 and the latter BC of 12·35 feet per Mile

LEVEL OF THE BED OF THE RANIPOOR RAO'

Diag: LXXXVIII. 1853

(Here insert Diag: No LXXXVII in Margin)

? - LXXXVIII
So marked on Sketch B

giving a mean on the whole distance

Note for the Printer

"Slope of Surface of Bed" be under ow. "Centre of Superpassage" above the figures

distance of 14.11 feet per mile
It is upon the mean slope that
the table of discharges above given
is calculated: and it is upon the
diminution of the slope from
B to C, or from the flooring of the
Superpassage downwards, that
I depend for the establishment
of deposits in the region of B,
or both on, and in the neighbor-
hood of, the floorings of the
Superpassage. —

The Ranipoor works were
built under the Superintendence
of Captain Goodwyn, by Mr Kay,
assistant Engineer, whose success
in managing the Torrent, and
in counteracting its effects upon
the defences, during the period
that the building was going
on, was most deservedly the theme
of universal admiration. —

The Puttri Superpassage
and the works connected with it

This work is similar in
design to that at Ranipoor with
the exception of the absence of
the Mile channel. There are
however, 9 Bays of equal dimen-
-sions, each of 25 feet in width;
that which constitutes the lock
chamber being 25 instead of
19 feet as at the Ranipoor works,
and the width of Superpassage
being 296 feet instead of 196.2"

The country which is
drained by the Puttri Rivers
or that which lying on the right
of the Canal constitutes the *
Catchment basin for the drain-
-age of which provision has to
be made, is bounded on the
north

741

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North by the Sewalik watershed, on the South by the Canal, on the East by the water shed of the Ramipoor Basin, and on the west by that of the Rutmoo & River; a careful inspection of Mr Dodsworth's Maps (Plate III of the Atlas) will shew very distinctly the connection, or partial connection rather, that exists between these 3 lines of drainage; the watersheds of each are accurately defined, but both in the case of the Ramipoor as lying on the boundary of the Puttri, and in that of the Puttri as resting upon the East of the Rutmoo basin; the natural separations of the drainage are very indistinct. As I have shewn in the early part of this history when describing the marked topographical features of the country, there is a direct slope from East to west, parallel to the line upon which the course of the Canal is carried; this slope affects the different basins more or less, and is very observable in the upper parts of the Puttri where from the levels of the surface, it would appear that the basins of the Puttri and Rutmoo are actually connected; and that as far as these levels are concerned the whole of the water that comes from the Sewaliks and which now passes down the Puttri, might with ease be thrown into the Rutmoo. The facility offered by this latitudinal slope for relieving one river at the expense of another has been before alluded to; and it is by no means impossible that

Alder

that it may be convenient here
-after to take advantage of these
facilities in relieving the Puttri
superpassage, by turning the
Bil supply towards the
Rutmoo Dam - This change of
direction would require careful
management, so as to prevent
the Torent from coming in
contact with the Canal on
that part of its Channel lying
on the west of the Gurh and
Tymbas ridge, or of its gaining
admission into the Channel by
the Badshahpoor Inlet, but at
the same time it is feasible,
and may be considered as a
resource in the event of the
Puttri superpassage being
overloaded -

The Catchment Basin
of the Puttri or the tract con-
-fined within the boundaries
before mentioned, has in the
design for the works which have
been constructed, been divided
into two distinct areas: One of
which is connected with the
Selimpoor line of Nulla, and
with a single tract of 10 Squar
Miles in superficial extent which
may be considered as subordinate
to, and lying to the East of the
true drainage of the Puttri, the
other the Puttri itself: the first
as being unconnected with the
Hills is remarkable for throwing
off pure water unmixed with
Sediment, the latter for its dis-
-gorgements of Sand and Silt,
marked by the true characteris-
-tics of Sewalik drainage.

The subordinate area which
may

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may be termed the Selimpoor basin, the extent of which is equal to 10 Square Miles, but which during very high floods is supposed to be liable to an accession of water from the neighboring Torrents, is provided with an Inlet of 150 feet in width situated on the Right bank of the Canal, the flood water, therefore, from this source will pass down the Canal Channel and obtain an escape at the Rutmoo Dam, it has been provided also that the floods in extraordinary cases should have the means of escape over the country situated to the South of, and opposite the Inlet, by openings ~~left~~ in its passage through the left Embankments of the Main Canal Channel. — The actual area of the catchment Basin, or the drainage of which the Superpassage has been constructed is therefore equal to 80 Square Miles minus that occupied by the Selimpoor basin of these remaining 70 Square Miles 40 may be considered as mountain and 30 ~~as~~ jungle and grass land, the latter lieing on a rapid slope directed upon the works. It is with these seventy Square Miles that the Superpassage which I am about to describe is specifically connected. —

Barnett

The Puttie Torrent so far differs from ~~that of~~ the Rampoor that whereas the latter is at the point of intersection with the Canal, a well defined and marked Channel, the former is merely known by extensive beds of Sand superficially distributed over the surface

surface of the country. There is however the same remarkable difference ~~in level~~ between the channels of slope, on the up stream, and ~~at that on the~~ down stream sides of the superpassage, and this difference is greater ~~less~~ in both cases at the Puttri works, ~~together~~ which with its position relatively to the Canal bed places it under even more serious ~~acute~~ difficulties than ~~those met~~ with at the Rampoor Torent. Its distance from the foot of the Hills is 5 Miles, that of the Rampoor work is 2 3/4 Miles. —

I have in the prefatory remarks on these Superpassages described the nature of the Embankments and Spurs which have been constructed in the valley of the Puttri for the purpose of bringing the floods to bear upon the Masonry works. I have also described the protective measures that have been taken at the points where they come in contact, for relieving the superpassage from the action of the current. It is unnecessary, therefore, to enter further on this subject, as the detail shewn in Plate XXIV of the Atlas will make this part of the project sufficiently intelligible.

It will be seen, however, by this Plate that the actual position of the superpassage is to the West of the natural line that the Torent has, during late years taken; this Westerly site was determined on for two reasons: 1st. that the work might be executed without hindrance during the period of floods; 2nd. that the deep excavation which had to be made from the Rutmoo back to the site of the Puttri works, might be reduced in length as much as

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Note for the Printer

A. Depth to which springs were reduced by drainage cuts.

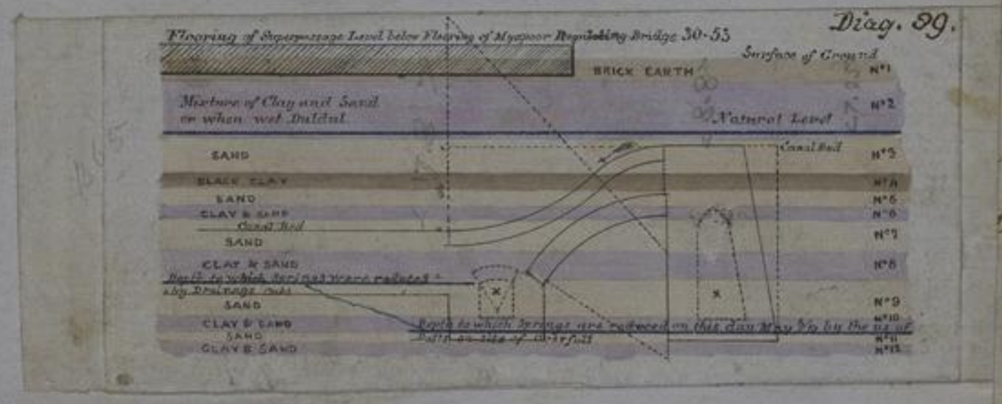
B Depth to which springs are reduced in this day May 6/51. by the use of Deller's Artesian Tube.

the rest outside

~~it~~ was possible ~~to do so~~. The Value in point of economy of the latter reason will be understood by referring to the following diagram which shews the nature of the soil through which the excavation for the Puttri Superpassage was carried, and the height at which Spring water was found.

Diag: LXXXIX

Section shewing the different strata of Earth at the Over Fall of the Puttri Superpassage



Edge of Cut

Now it will be seen from the above Diagram that the actual depth of digging from the surface of the Country to the Canal bed on the higher levels was 8·8, that, to gain the lower levels, was 17·8 feet. To reach the levels on which the Curtain and ogee foundations rested, the depths to be dug was 28·8 feet, that of the floorings on the greater part of their extent was 23·8, on the lesser part 22·8: the tail foundations had to be sunk to a depth of 37·8 feet from the surface of the Country, below which there was Spring water at a depth of 7·25 feet ~~Nearly~~

Plate XXIV. Sheet b of the Atlas gives an outline of the Floods of 1850, and their effects upon the Puttri works, which previously to the rainy season of that Year had been commenced, by the establish-

-ment

=ment of Embankments for the protection of the works, and by the formation of a channel 300 feet in width to which it was intended to limit the Torrent — The different works that were con=structed at this period are shewn in the Plan above alluded to —

The effects during this season appear in their action to have been quite independ of any of our proceedings; the Current in an early part of its course and high up on the bed of the River spread over the Country taking a direction to the East, and to that point of the Canal where the Selimpoor Inlet is now built, a considerable portion of the current in fact, passed into this portion of land which has been designated the Selimpoor basin; here it crossed the Canal banks which had been partly formed, and filling in a good deal of the ex=cavated Channel, swept over the country, leaving breaches through the banks as are shewn in the Plan — The main body of water, however, continued in the direction of the 300 feet opening which had been left for its reception, through which, during the greater part of the season, it passed, with=out injuring the flank defences, excepting on one occasion when it broke into the superpassage without doing any material damage — On the 29th September 1830 however, in defiance of ~~the~~ the Engineer's defensive works, a flood which occurred during the night time, carried away the left flank of the opening entirely, and widened the Channel to an extent of

of 147 feet. The general effect of the passage of the Current through the opening during this period was undoubtedly to deepen the Channel where it was most contracted, and the extent to which this took place is shewn in Fig. 2 of the plate above referred to. During the rainy seasons of 1851, 1852 and 1853, the Torrent has still in a greater or less degree passed off in the divided streams it having been thought advisable for the Security of the Superpassage during its construction, to leave the breaches open, and by these means to give relief to the passage of the water at points distinct from the Masonry works. In this manner the floods for 3 years have gone bye without giving any trouble. The bed of the Opening has during this period, although passing off large volumes of water, experienced a variety of changes, and at the time that I am now writing (1853/54) is above its original level, being covered with Sand deposits as it was previously to the floods of 1830.

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Plate

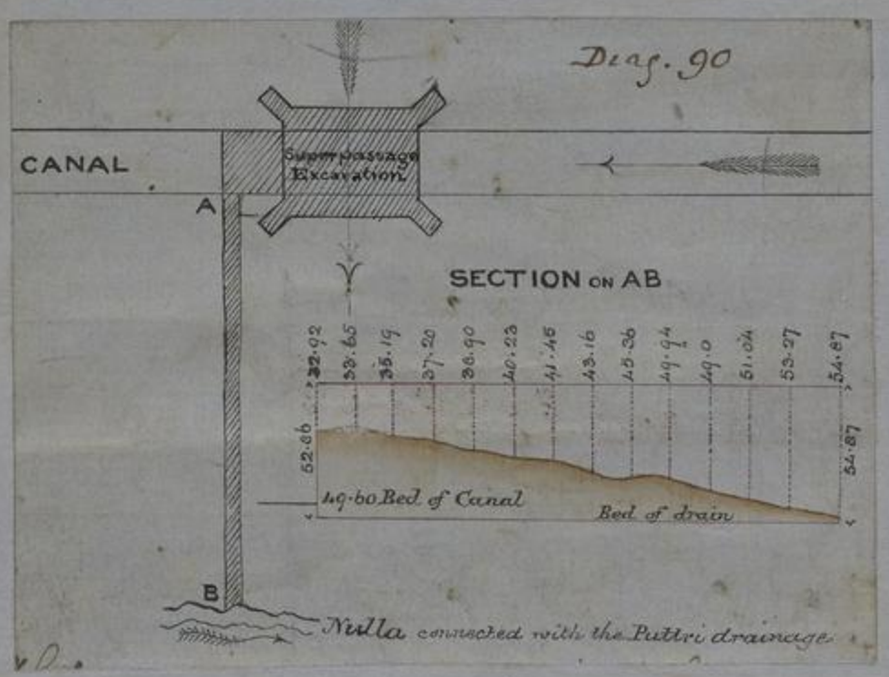
The great(st may be said ordinary) difficulties that Engineer in charge had to contend ost in laying in the Masonry is work, must under the above ined circumstances, be evident. gen however succeeded in reducing ring water level to a depth of 18·25.

feet from the Surface of the Country, and in laying in the whole of the building, foundations included

included, with little or no impediments from water. The tail foundations which consisted of blocks of masonry were undersunk to a depth of 20 feet, and those portions of the curtain and ogee walls below the reduced Spring level were laid in by the use of Dalls, or scoops by which the water was entirely removed from the excavations.—

The situation of the canal, (crossing at right angles a country lying on a rapid slope) was particularly favorable to the operations for drainage, and this was taken advantage of in the most economical way by making a cut from the Canal bed in the direction of the slope; and as the Spring water passed away, gradually deepening both the excavations for the works and for the drainage, until the water was reduced to a minimum. The Plan adopted ~~by Baylagio~~ is shewn in the following diagram, accompanied by a profile of the country on which the drainage cut A B was excavated.—

Diag. 90



The design was simple, and its success complete. I am not aware that during the whole of the

Note to the printer

The words "Section on A.B" and the row of figures ~~to be~~ set up over the block and the words "Bed of drain" below it. The words "Nulla connected with" as a below the block

750

the building operations any further difficulty existed than in the maintenance of the drainage cut as a free and open line. This as might be expected was on its lower levels subject to the falling in of earth from its side and to deposits of mud and sand from the action of springs and current. There was a constant necessity for working parties being employed upon it, but the free passage of the spring waters which it secured, rendered the progress of building comparatively easy.

The soil upon which the masonry rests is far from being a satisfactory one: the circumstance alone of its being ~~saturated~~ impregnated with springs, independently of the soil itself in which the springs act, being composed of a mixture of sand and clay, is an evil of great magnitude. I have trusted, however, to the massiveness of proportions of the foundations and to the extensive surface which they cover, equal in area to 331½ × 285 or 94477½ Square feet as a protection against any serious disarrangement of the superstructure by after settlement. The result however has not proved so satisfactory as could have been wished, the line of Blocks at the tail has led to a slight settlement arising, I imagine, from the crater like form which is given to the soil in the progress of undersinking, and consequently (in all probability) to an inclination that these solid masses have to-

to move after the superincumb-
=bent weight was placed upon
them. The flooring of the left
Chamber, or of that ~~which is~~
devoted to Lock purposes which
from motives of economy was
reduced in thickness to 2½ feet
has also slightly settled; these
defects, however, will not, I
imagine, act prejudicially, nor
will the settlements proceed
further than it has already
done. —

The building is constructed
entirely of brick (12" × 6" × 2½"
in Cubic measurement, burned
in the Selimpoor manufactories)
and boulders, the latter being
used in all the massive parts
of the foundation; the former
in the outer surface (18 inches thick)
of the ogees and floorings, and
in the superstructure. The cen-
-terings for the arches were formed
of earth well watered, on the na-
-tive plan, which has, as a
general rule, been adopted through
-out these works. With certain
disadvantages which are noted
in the Chapter on Bridges, this
species of centering has the
great recommendation of
cheapness, added to a facility of
adaptation to the purpose,
which no other species of center
-ing offers. — The boulders of which
the foundations are built, and
which are so extensively used
in the protective works appended
to the Superpassage, were col-
-lected at the mouths of the
passes into the Sewaliks and from
the bed of the Ganges River, from
whence

7.51

whence they were carted to the works at a cost varying from Rs 1/8 as per 100 Maunds, from a distance of from 5 to 7 Miles, or from 8 to 9 Shillings per 3/2 Tons.

The following Quantity of Material was expended

Bricks — 12"×6"×2½"		9411011	
— Do —	English machine	3661444	
Boulders		1404262	Maunds
Khanna		23248	Cubic feet
Stone Lime		285757	— do
Sookee		408445	do
Sand		80479	do

and the proportions used in the Cement were as follows.

Boulder Masonry	1 Stone Lime 1 Sookee 1 well washed Sand
Brick Masonry	1 Stone Lime 2 Sookee
Protective works	Plaster
10 Stone Lime 10 Sookee 10 Sand 5 Lime Siftings 5 Small broken Brick	3 Stone Lime 2 Sookee The whole being finished off with a coat of 27 parts of Stone Lime to 1 of Sookee

The rates of work performed will be shewn in the following Table

Total Cubic Content of Masonry 2241359/1 Cubic feet

Rich Masonry	23	15	1	per 100 Cubic feet
Brick on Edge do	19	1	2	per do
Plain do	16	13	8	per do
Plaster	2	3	5	per 100 Sq feet

Alder The calculations for the discharge through the Channel of the Superpassage have been made on the Plan before described for that of the Ramipoor work; the effective slope being estimated on the mean of Two of 4 Miles, two of which are on the upstream and two on the down stream side of the Masonry Channel; the sections which accompany the present description have

have been taken since the works have been completed, they shew therefore, the true declivity of country in connection with the works, and fully exhibit the diminution of slope on the down stream side, as tending to deposits in the region of the Masonry work. Taking the mean of the slopes on 4 Miles as 25·13' per Mile the following table will shew the value of the Putti passage in its capabilities of discharge to a depth of 10 feet of water on its floorings.—

		Velocity				
D	R	V	u	U	Area	Discharge per Second
1	11·919	7·152	10·024	4·280	296	2116·992
2	23·680	10·172	13·631	6·713	592	6021·824
3	35·285	12·466	16·314	8·618	888	11069·808
4	46·737	14·381	18·576	10·246	1184	17027·104
5	58·039	16·052	20·411	11·693	1480	23756·960
6	69·195	17·542	22·118	12·896	1776	31154·592
7	80·206	18·908	23·649	14·167	2072	39177·376
8	91·077	20·113	25·030	15·196	2368	47827·584
9	101·809	21·331	26·367	16·295	2664	56825·784
10	112·405	22·288	27·437	17·133	2960	65963·600

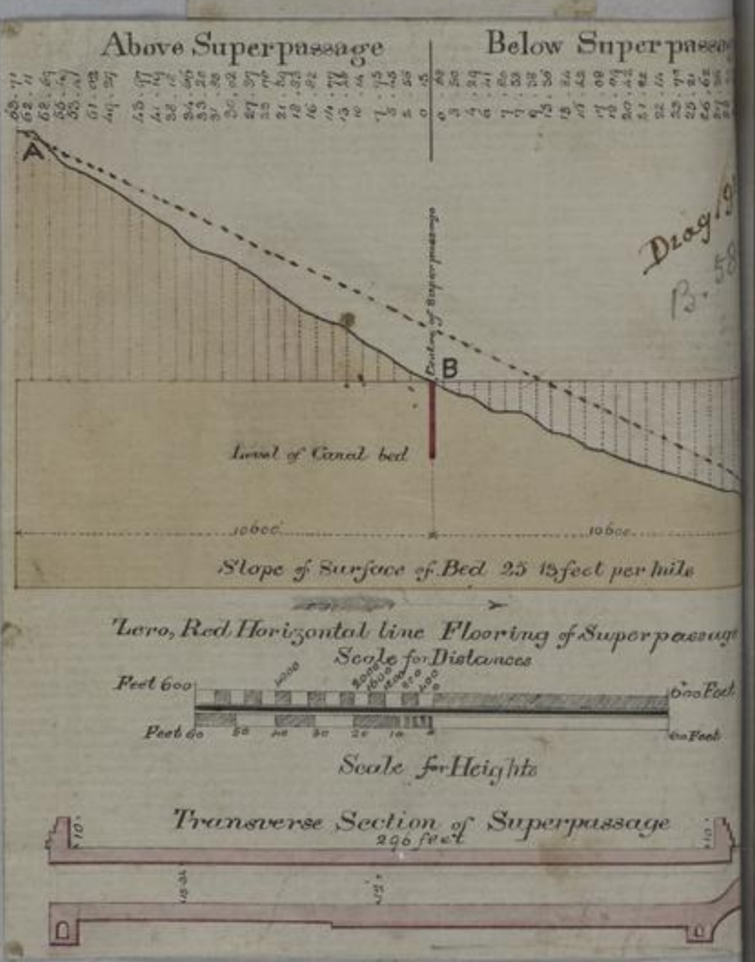
The above Table is calculated from the mean slope obtained from the following section, which shews that the Slope of approach A B is equal to 31·73 feet per Mile, and that of departure B C equal to 18·53 feet per Mile—

Diag XCI

LEVEL OF THE BED OF THE PUTTRI NUDDI
Diag: XCI. 1853

The suppositious dotted line A C which represents the mean slope upon which the calculations of discharge are

Dr 2600
B. 58



are founded exhibits also the theoretical boundary to the extent of deposits on B.—

Barnett

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The Establishment for the Supervision of the Superpassages will be connected with that of the line of Navigation which runs parallel to them, they will be under the immediate charge of an Overseer whose duties will extend from the Dowalapoor Bridge on the upstream side of which the Navigable line commences, to the downstream side of the Puttie Superpassage, at which point the Navigable line terminates. To each of the 4 Locks, 2 of which are connected with the Superpassage buildings, a gang consisting of 1 Mate and 10 Beldars will be attached, giving to the whole line a purity of 4 Mates and 40 Beldars.— Independently of the Lock duties and the management of the Navigable Channel, the overseer will be expected to maintain the Embankments and roads within the limits above specified in a perfect state of order as regards the annual repairs and jungle clearances.

V. The Inlets which form a component part of the Bridge and of the Rajbuha Channels

---

I have before noted that after the Canal reaches the high land of the Doab, the principle

principle upon which the works has been designed, precludes as much as possible the occurrence of Inlet water; all flood water and country drainage are thrown into the beds of Rivers to which they are the natural Escapes for them: and the works for Inlet on the Canal Channel are confined to the relief of the land lying in the immediate neighborhood of the works. The Inlets, in fact, from Roorkee downwards consist entirely of Masonry Channels, either attached to and forming component parts of Bridges, or built in connection with the navigable Channels that pass round the Falls. All the Inlets of this description have been so arranged that the admission of water into the Canal Channel should be through an opening, either in a line of Revetment or wall of some description or other, so that the effects of a current upon the isolated head of a detached building might neither disfigure the Channel in the vicinity of the Inlet, nor lead to deviations in current which projecting parts of Masonry are very apt to be the cause of.—

With this view the Inlets which consist of a Channel 3 feet in width, terminating in a Circular Well or Reservoir which acts as the receiver; are built universally, either in connection with Bridges, attached to the waste

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waste Channel of locks, or with their Channel passing through a Ghat, the steps of which act as a curtain of defence on the Canal ~~Channel~~ vide.

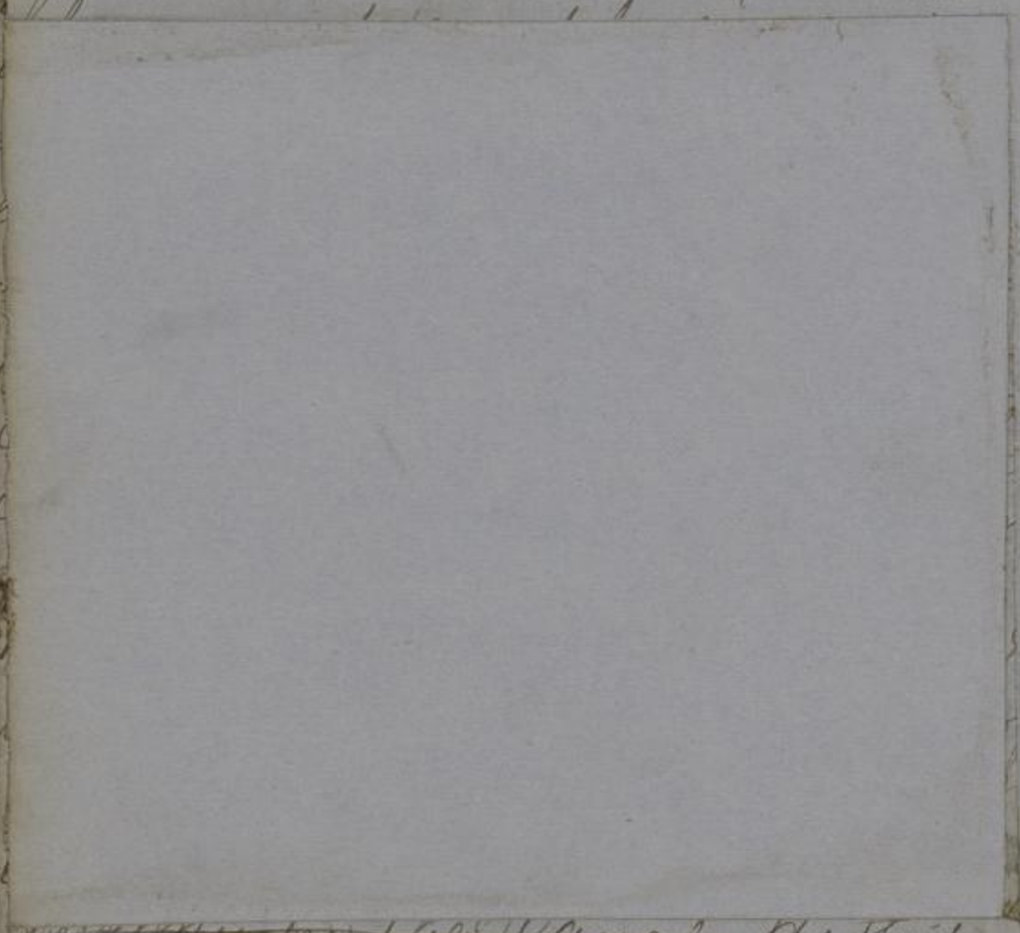
The Bridge Inlets are placed in the position shewn at X in the following Diagram. XCII

The roadways of Bridges throughout the whole of the works are horizontal, and the ramps of approach are constructed on a slope of 2 feet in a hundred, excepting on the lines where the grand Trunk Road crosses the Canal in which case the slope is reduced to 1 in 100. - the Elevation of the Bridge roadways therefore, above the Surface of the country varies with the depth of Canal excavation; taking it in extremes, the maximum is 18 feet, and the minimum is 6, the average height may be estimated at 8 feet; it is clear, therefore, that as the slope of the country and that of the Canal are in one direction, the intervention of the Ramps of the

Bridges

Bridges must in their immediate locality interfere largely with the drainage; To remedy this interference, the above species of Inlet was devised, the top of the well at × being in all cases on a level with the high water mark of the Canal. Wherever (as was the case at Kunkhul as described the former section) the surface of external country in the neighbourhood of × is low, a sluice with shutters arranged in the side of the well so that during periods of low water in the Canal Channel, the Inlet may be turned to account —

It will be observed that the Inlet Channel opens into the Rajbuha, by which it will naturally escape, without interfering at all with the supply in the



~~supply to the Canal~~. As this is a point which requires regulating, I have in addition to the necessary sluice arrangements at the head of the Rajbuha vide a a in the diagram, placed corresponding ones on the down stream side of the Channel at b.b. So that if necessary means may be offered for preventing the Inlet water from passing down the Rajbuha, by closing the sluices at b.b. and leaving those at the head open. — This double plan of sluices enables the Supervising Establishment to regulate the disposal of the water, according to the exigencies of the moment. There will be times when the relief by the Rajbuha Channels will be

be

plumb

be of the greatest benefit; at other times it might be incon=venient from the Rajbuha Chan=nel being out of order, to allow water to pass down it. At any rate, the mere fact of holding the power of doing as we please with the water is an advantage which cannot be too highly es=timated.—

Independently of the mere drainage water which is inter=cepted by the Bridge ramps the boundary ditches of the canal must necessarily tend to bring down a supply from the Canal bank and land lying in its neighborhood; the Inlets will be of great service in dis=posing of this water, and as the Canal Chokies in all cases are built not far from the In=let Head, and in the Angle formed by the Canal Embank=ment and the Bridge ramps on its up stream side, the ground in their vicinity can always be kept high and dry and entirely free from standing water. The Bridge Inlets are, in fact, admi=rable auxiliaries to the System of external drainage, and will, it is to be hoped, relieve the works from all superfluous water!—

Drains similar in design to those above mentioned are attached to the works on the Solani aqueduct in the neigh=borhood of Roorkee. The work=shop Yard, and the Esplanade in front of the main buildings have their drainage disposed

of

of, by wells connected with the Canal by underground Chan-nels. Similar Inlets are also attached to the Cattle Pens for the drainage of the Country in their vicinity.-

The Esplanades on the Right and Left of the Canal on its approach to the Ganges at Cawnpoor have inlets designed on the same plan, for their drain-age as well as for that of the Town and Bazaars which run parallel to them

The Space inclosed by the navigable Cuts which are de-signed for the passage of craft at the points on the Canal & where the great descents or falls occur, is drained by Inlets of a similar description to those above mentioned. These Inlets are connected with the waste Channels of the Locks, and the rain water that falls upon the surface included be-tween the line of Main Canal and that of the Cut, is brought to bear upon the mouths of the drains by excavated Channels. In the Event, however, of the above islands not being Suffi--ciently drained by the Lock In-lets, the centrical situation of which may in some cases be inconvenient, I see no harm in supplemental drains being con-structed at points near the junction of the Navigable with the main Line; these Inlet drains would open into the Navigable or Lock Channel, in which the body of water is comparatively

Small

small, and the consequent ac-
-tion of Current moderate, their
Canal Ports might with great
~~Propriety~~ ~~Advantage~~ be protected by a
line of Ghat, the advantage of
which in affording an approach
to the water ~~can never be too highly~~ will always be highly appreciated
~~by Estimated~~ by the native community; — As these well
heads would be connected with
the natural Surface of the country
generally speaking on its lowest
levels, the effect upon the drain-
-age of the Island would un-
-doubtedly be beneficial. It will
be evident, however, that in addi-
-dition to the value derived from
these well headed drains as Inlets
for flood waters, they act during
dry weather in affording access
to the Canal Supply for various
purposes. The Mangoe graft
Plantations are invariably situ-
-ated near the Bridge Inlets; and
the Nurseries of Forest trees, and
Plantations for Brushwood are
in all cases spread over the island
formed by the Main and naviga-
-ble Canals; to the whole of these
Plantations they would afford
the means of Irrigation. The
Multiplication of this species
of Inlet in connection with the
Islands may possibly be econ-
-omically convenient as afford-
-ing the means of Irrigation to
tracts of plantations scattered
over extended Surfaces; I am by
no means satisfied that this
might not have been done
with advantage in the first
instance, although motives
of economy prevented me from
~~building them~~ putting it in practice.

The

The only species of Inlet remaining to be described is that in Connection with the Bridge Roadways which in their passage over the Canal are shut; the drainage here is effected by vertical holes perforated through the crowns of the arches, whereby the rain water passes off into the Canal Channel. This method of disposing of roadway drainage is preferable in every respect to that of carrying off the water by side Channels, which are invariably troublesome, and in many cases inconvenient. —

Part 3

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CHAPTER, II

Regulating Works for the Supply of Water and Slope of Channel.

This Chapter may be divided into four Sections.

i. Regulating Bridges.
ii. Heads of Branches.
iii. Escapes.
iv. Falls.

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Under the ~~preceding above~~, I include all works of the above description which are distinctly connected with the regulation of the Canal supply for the purposes of Irrigation. It is impossible to draw a precise line between the first three items of the present and those described in the last ~~paragraph~~ chapter; they do in fact during floods act either in maintaining a convenient distribution of the superfluous water, or as in the case of the Escapes, in getting rid of it altogether; so under the head of Dams, which naturally fall under the denomination of drainage, works of this description afford the means of regulating the supply for Irrigation during the dry months, as well as of relieving the Channel from the torrents with which it comes in contact during the rains; the Regulating Bridges, moreover, are as distinctly a component part of the Dams, as the Sluices

in

in the Dams themselves, and are as necessary a part of their machinery during floods, as the Sluices them-selves are. - It will, however, be understood that the present Chapter is specifically devoted to the supply for Irrigation supply, whilst that on drainage ~~works~~ is con-fined to those for the relief of the Canal Channel from what we may call Torent water. -

I. Regulating Bridges

With the exception of the Dubooli and Moosanuggur Regulators which are connected with the Terminal works of the Cawnpoor and Etawah Lines, un-der which head they are described, this section is limited to

A - Myapoor Regulator
B - Dhunowri Do

the details of which have been fully entered into in the last Chapter. - For drainage purposes, these works act as Dams across the Canal Channel for preventing either the floods ~~from~~ of the Ganges or those ~~from~~ of the Rutmoo River from gaining admission into it. They confine the Torents to their own courses and for this purpose they are of the highest importance. For Irrigation purposes, the Regu-lators at the above points, admit during the dry season of the sup-ply being adjusted to the provi-sional demands for Irrigation, and in the Event of accident to the Masonry works, or ~~to~~ of a necessity for repair to the Channel, they provide the means of turning the

the water off altogether, and of laying the Canal perfectly dry To insure the satisfactory and ready accomplishment of all the details dependant on the working of the machinery for closing and opening the Regu-=lators, permanent working parties consisting of 4 Mates and 40 Belders, are attached to each of the Bridges - These par-=ties will be under the imme-=diate control of an Overseer resident on the Spot, who will subject them to discipline in periodical drill in working the apparatus both of the Dam and Regulators; monthly, or oftener if necessary, an Inspection of this part of their duty ought to take place under the eye of the Executive Engineer of the Division; and the Director of the works would on his periodical visits consider a parade of the whole party, with the evolutions attendant upon the opening out and closing of the Dam and Regulators, a ceremony with which he ought to be received, on his reaching the works.

It is, I believe, impossible to place too much weight on the necessity for maintaining these Corps of working parties in the most efficient state of discipline, the safety of the works will de-=pend upon it, and the whole country may have to deplore the negligence or incapacity of the working Establishments of the Regulators - I should be inclined to select one of the best

best and steadiest overseers for the charge of each of these works, and endeavour to make it a post of honor, as I would of Emolument, by giving each overseer an addition to his month-ly pay of 20 Rupies, ~~providing in addition to~~ for him also accommodations ~~for him~~ at the Public Expense; the duties of these Overseers would be to look to the efficiency (including Physical Strength) of the Party under his orders, to see to its being properly [drilled, and to its discipline being maintained under orders ~~which should be issued to be~~ provided by the Executive Engineer of the Division.—

At Nyapoor the Overseers duties would extend from the Ganges (to the bunds and Embankments on which his attention would be given) to the upstream side of the Dowlapoor Bridge: and it is supposed that during the dry periods of the year when the Dams and Regulators were little used, the Beldars who are divided into 4 Gangs, consisting of 1 Mate and 10 Men each would be sufficient to maintain the whole of the Roads and the whole of the Embankments in a State of the highest order and tidyness

At Dhurowri the Overseers duties would extend from the Puttri Sulphi passage on its down-Stream side to the upstream termination of the Solani Aqueduct works, the total distance being 6½ Miles; the remark that I have made

with

with regard to the duties of the Beldars during the dry season, would be equally applicable here; and I imagine that the whole of the roads, embankments and space between the Canal boundaries, including the Esplanades connected with the works at Dhunowri, may be kept in the most perfect state of order by the Beldar parties. One of the chief duties of the Overseer at this post, will be to see to the efficient working of the under Channels at the Regulator, to take care that they are maintained in a free and unimpeded state, and that no inundation is allowed to collect above the works. Rules on this subject together with Regulations for the discipline of the Beldars might with great advantage be printed and hung up in the Public buildings. I would recommend that these Rules and Regulations be printed in Hindi and Urdoo as well as in English.

II. Heads of Branches

These works are in form identical with the Regulators described in the last Section, their purposes however, are merely those of regulating the supply of water from the Main Trunk to the Branches. They are useful in giving us the power of stopping supply altogether, when laying the Branch dry for repairs. They are equally useful

useful when the supply does not exceed the capacity of the Branch in laying the Main Trunk dry, and of converting the branch into an Escape. Collectively they may relieve the main Trunk and with the aid of the Escapes do all that is required without the aid of the Regulators described in the 1st Section. Practice and the Electric Telegraph will render these works of the highest value and importance to the Regulation of Supply. They come under the following heads

A. Head of the Futtiguh Branch
B. Do Bolundshuhur do
C. Do Koel do
D. Works at the Nanoon Fork connected with the Terminal lines to the Ganges and the Dumna.

A. The Futtiguh Branch leaves the main Trunk on the left at the 50th Mile of its course at an angle of 60° degrees; its supply is calculated at 1240 Cubic feet pr second, and the main Trunk after having disposed of this supply passes onwards in a volume equal to 5180 Cubic feet pr second. The slopes of the Channels of both the branch and main Trunk are equal to 15 Inches pr Mile, and the soil through which they pass consists of a combination of clay and sand in which the latter predominates.

I have in Diagram XIX in the 2nd part of this Paper given an outline of the works attached to the Branch Heads.

They

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they consist of Bridges with Shutters, placed both across the Canal immediately below the departure of the branch, and across the head of the branch itself, the upstream wings of the two bridges being connected by a curved Masonry Revetment. and as high as the level of the berm, with a redan shaped retaining wall, forming an angle equal to that of the de= =parture of the branch, salient to the stream - The two sides of this Redan, are designed in Shute or flights of steps, which give the means of access to the Canal water from the Esplanade ~~which~~ lies on a level with the berm; the higher levels or platforms ~~which~~ corresponding with the road = ways of the Bridges are reached by Stairs laterally arranged in the curved wall ~~which connects~~ connecting the wings

A 1st Class Choki building is erected on the delta formed by the main Trunk and the Branch, ~~the~~ axis being obtained ~~is found~~ by bisecting the Salient angle of the redan; ~~to~~ this axis and at a distance from the Angle, vary = ing according to circumstances the Choki building is laid out Square and Parallel. -

The Bridges are in all cases furnished with Masonry floors in Counter arch resting on deep curtain walls carried across the Canal Channel on both the up and down stream side of the Bridges, and with protective lines ~~of~~ either of sheet piling

piling or walls, the intermediate space being filled with heavy material, on the same plan as has been described elsewhere. The flanks of these bridges are also covered by either piling or retaining walls, and throughout the whole of the series there has been no deviation from the standard plan as originally laid down.

The gates and apparatus for opening and shutting are precisely the same as those which have been figured in Diagram Fig 1 of the last Chapter. They consist of a drop Gate 6 feet in depth which is held in suspension by bar chains fixed to windlasses. On closing the Canal these gates are relieved from their suspended position, by raising the ratchet catches with the end of a marlin spike, the attached chains being afterwards removed by ~~a boat hook~~ the hooks being detached from the gates by a lateral movement; Keepers are dropped one above another on the top of the gate until the bay is sufficiently closed; ~~There~~ To close and open one of these bays with the apparatus above described, the time occupied is about 33 minutes and considering that in the case of the Branch heads time is of less importance than it is at the Dam Regulators, and that leakage is, to a certain extent, of no consideration at all, the ~~arrangements~~ Establishment that is provided for the working of the Machinery will do ample

justice

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justice to the design, simple as it is, and as it ought to be.—

The above is a general out=line of the whole of these works which vary in no material de=gree beyond that of extent of waterway to the Bridges, and in the value of the Angle of departure.—

The Regulator over the Main Canal at the Rattigunda Branch Head, has 9 Bays of 20 feet in width each, the height of each bay being 17 feet from the floor=ing to the soffit of the arch.— That over the Branch Head has 4 Bays of the same dimensions. The maximum height of + water with a full supply in the Canal is equal to 50 feet, in which case the lower 7 feet of the Branch bays would be closed, so as to admit of the full quota being given to it by an overfall 3 feet in depth flow=ing over weir fashion over the tops of the sleepers. A depth of 3 feet falling freely as in the above case from a Reservoir would give a discharge per second for each 20 feet opening equal to 352·92 Cubic feet, or for 4 openings 1411·68 Cubic feet per second, the legitimate supply being 1240. I have not thought it worth while, however, to graduate the discharges below equal depths of six inches; a division which for all practical purposes will, for sometime at least, be sufficient.— With 4 bays at the Superintendents dis=posal, however, he will be able

to

to regulate the discharge in a variety of ways, but when the branch is not required for navigating purposes the method above described affords the simplest, and at the same time the most accurate measurement

The widths of the roadways of the above Bridges is 18 feet and they provide communication between the Town of Mozufurnuggur and the Sooburtal Ghat on the Ganges, on the high and direct road between the former Town and that of Bijnore

The works are built entirely of Brick Masonry, from Bricks manufactured in Native Kilns established in the neighborhood; the Size of brick being 12" x 6" x 3" The grooves for the gates and sleepers are lined with slabs of Agra Sandstone, with which the Cut waters in which the Bite heads rest are capped.

The proportions of Materials used in the Cement are as follows

2 Parts of Earth Lime)
1 " Sookee)

those for Stuccoe or plaister are

1st Coat { 1½ Parts Stone Lime / 1 " Sookee
2nd " { 2 Parts Stone Lime / 1 " Sookee
3d " { 7 Parts best White Stone Lime / 1 " Sookee

The quantity of material and the rates charged for the different Species of work will be found in the following Table.

	Content of work		materials		
	Cubic feet of Masonry	Square feet Plaister	Bricks number as	Earth Lime	Sookee
Masonry	136046	33568	1020345	Cub. feet 45349	cub. feet 22674

	Rs	as	p	
Arch Masonry	14	8	4	pr 100 Cubic ft
Plain " "	12	1	5	pr " "
Plastering	4	9	9⅜	pr 100 Sq. feet

The total cost agreeably to the Bills of the Executive Officers was

Masonry	20262	5	10
Protection work	6078	3	2
Earthwork	1531	1	9
Plastering	1548	13	6
Metalling	350	4	"
Probable cost of work Title to be done	4876	"	"
Total Co Rs	34646	14	3

The work was commenced under the Superviscion of Lieut C Fraser of the Engineers, and completed under that of his Successor Mr Read.—

B. The Bolundshuhur Branch leaves the Canal on the right bank, at an angle of de-parture of 60 degrees; it is situ-ated at the 110½ mile from the Nyajoor Regulator.—

The Bridge over the Canal has 8 bays of 20 feet in width each, the height of each bay being 14 feet from the flooring to the soffit of the arch. That over the Branch consists of 1 Centre bay of 20 feet in width, and 2 side ones of 15 feet each; the total width of waterway being 50 feet, the height of these bays is the same as that of the Canal Regulator The Roadways over the bridges are 18 feet in width, and they afford communication between Delhi and Gurmooktesser.—

The supply for this Branch is equal to 520 Cubic feet per second, and the main trunk after having disposed of this sup-ply passes onwards in a volume equal to 4330 Cub. feet.— The slopes of the Channel of both the Canal and branch are at the point of separation equal to 15 Inches per

per Mile; the soil is of a consistency like that at the Futtigunk head; the foundations however, are laid in sand, but well protected.

In other respects the detail of construction is similar to that which I have described as the standard for all works of this description.

The maximum high water which will stand upon the Regulator at the Bolundshuhur Branch head is theoretically equal to 8 feet. For the supply of the Branch under such circumstances, it is sufficient to give a superficial flow over the gates and sleepers (which would be adjusted accordingly) equal to 2 feet in depth; this agreeably to the formula of discharge which has been used throughout these calculations would be equal to 479.4 Cubic Feet per second.

These works are with the exception of the Arches built entirely of blocks of Kunkur, brought from the Quarries at Bheel and Dotara. The Arches are of brick of the size used at the Futtigunk Branch head. The grooves are lined, and capped with Agra Sandstone slabs, and the whole work is externally stuccoed.

The proportions of material used in the Cement are:-

1 part Kunkur Lime to
1/20th of White Stone Lime

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	Contents of work		Materials			
	Cubic Feet of Masonry	Square Feet of Plaster	3 Inch Bricks	Block in Kunkur	Stone Lime	Kunkur Lime
				mds	mds	mds
ry	102817	48552	282204	110132	191	28621

Rubble Masonry	16	..	.	per 100 Cubic feet
Ditto — Do —	13	7	"	do
Plastering	2	5	½	per 100 Square feet
Metalling	2	..	..	per do
Bitheads	15	..	.	each
Windlasses	30	.	.	do

The quantity of material and the rates charged for the different Species of work, will be found in the following Table. ※

The total cost agreeably to the Bills submitted is as follows

Masonry	14818	15	8
Plastering	1122	12	3
Metalling Approaches	210	..	..
Protection	1555	14	5
Woodwork	1050	..	..
Required to complete Woodwork	2000	..	..
Total Company's Rupees	20757	10	4

This work was begun and completed by Mr Philips Volk, the Officer in Executive charge of the ~~Works~~ Division.

C The Koel Branch leaves the Canal on the right at the 152nd Mile from the Mynapoor Regulator. With exception of the Bridge over the main trunk having only 6 instead of 8 bays of 20 feet each, the Koel branch works are in every way similar to those at the Bolundshuhur Head, the angle of departure and the slope of bed being the same in both cases. The width of Road-ways is the same, and the distribution of kunkur and brick work in the construction of the buildings is the same proportion.

The Koel branch Head affords a cross line of communication between Chandos and Anoopshuhur

The maximum high water on the Koel Regulators, agreeably to the Table of discharge is equal to 8 feet; the supply for the Branch is equal to 520 Cubic feet per Second obtained as in the case of the Bolundshuhur Head, by an overfall on the sleepers of

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2 feet in depth. The head itself having a total waterway of 50 feet in width. After disposing of the supply to the Koel Branch, the main Trunk proceeds onwards carrying a volume equal to 3530 Cubic feet per second.

The proportions of Material used in the cement are as follows

1 part Kunkur Lime. to
20 lb of White Stone Lime

The total Quantity of Materials used, together with rates of the different descriptions of work are shewn in the following Table

	Contents of Work		Material Expended			
	Cubic Feet of Masonry	Square Feet of Plaster	3 Inch Bricks	13 lb Kunkur mas	Stone Lime mas	Kunkur Lime mas
Masonry	87149	45508	152445	93100	2362½	25385

Rates					
	Arch Masonry	16	..	..	per 100 Cubic Feet
	Other Do	14	14	8	per do
	Plastering	2	3	5	per 100 Square feet
	metalling	2	..	..	per do
	Bitt Heads	15	..	.	each
	Windlasses	30	..	..	do

The total Cost agreeably to the Bills submitted is

Masonry	11378	1	3
Plastering	1008	..	9
Metalling approaches	514	12	9
Protection	2727	..	..
Wood work.	1125	..	..
Required to complete Wood & Iron work	1500	..	..
Total Comp^y's Rupees	18252	14	9

The Koel Branch Head works were begun and completed under the Management of Mr Philip Polk

D. Works at the Nanoon Fork

In principle and design these works are similar to

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to those before described; they con=
=stitute the Heads of the Two terminal
lines into which the Main Trunk
is divided on its reaching the 180th
Mile of its course. Whereas, therefore,
the Futtiguch, Bolundshuhur, and
Koel Branch Heads may be
considered as subordinate to the
works on the Main Trunk, those
that I am now about to describe
are a component part of it. The
position of the 2 Heads with
reference to the main Canal
on its approach to the point
of separation, is laid down
with a view to obtaining for
each of them, an equal supply
of water. For this purpose, the
longitudinal axis of the main
Canal, bears centrically upon the
Salient angle which separates
the two heads; the axis in fact bi=
=sects the Salient angle, and by
so doing, gives an equable ad=
=justment to the Current in its
bearing upon the two heads. The
Slopes of the Canal bed being
equal, viz: 15 inches per mile; the
angle of incidence and departure
being adjusted as before described,
and the Capacities of the bays
of the Regulating bridges them=
=selves being of equal dimensions;
the effects of the wear upon the
beds of the Channels immediately
below the Bridges, appear to be
the only probable source of
~~from~~ disarrangement.—

The Canal supply on its
reaching the Nanoon Fork
will amount to 3250 Cubic feet
per second; and it is supposed
that

that the depth of water under this supply will be equal to 8 feet. It is needless to discuss the methods of regulating the admission of the Canal waters into the heads of the Terminal lines, or to detail the uses that may be made of each separate regulator, further than to say that the means are provided for playing either one or other of the Branches dry, and that this can be effected under any amount of supply in the Main Trunk by the aid of the Escapes which lie immediately above them.—

The 1st class Chokis in consequence of the above described position of the axis of the Main Trunk, and from the form on which the designs of these works are lined out, being built on the axis, has an aspect bearing directly upon the alignement of the Main Channel. The Bridge Roadways are 25 feet in width, and they are crossed by the Grand Trunk Road in its passage from Cawnpoor to Alleguck.—

These works are with the exception of the arches built entirely of Kunkur; the arches are of brick of the usual dimensions of 12" × 6" × 3".—

The proportions of materials used in the Cement are as follows.—

1 part of Kunkur Lime to 1/20th of White Stone Lime.—

The total Quantity of Materials as well as the rates at which the

the work was executed, will be seen by the following Table

	Content of Work		Materials Expended			
	Cubic Feet of Masonry	Square Feet of Plaster	3 Inch Bricks	Block Kunkur mds	Rough Lime mds	Hewn Lime mds
masonry	132228	43772	228400	103325	105	36137

Rates	Arch Masonry	15	..	.	per 100 Cubic Feet
	Other do	12	..	10	per do
	Plastering	1	13	6	per 100 Square Feet
	Metalling	1	9	..	per do
	Bitt Heads	15	..	.	each
	Windlasses	30	..	.	do

The total cost agreeably to the bills submitted is

Masonry work	14884	7	6
Plastering	807	1	7
Metalling approaches &c	2138	9	..
Protection	2074	12	10
Woodwork	960	..	.
Required to complete Wood & Ironwork	1500	..	.
Total Cost Rupees	22364	14	11

The Nanoor Regulators were began and completed by Lieut Merrick of the 3rd Regiment of Native Infantry under the supervision of Mr Philip Volk.

A question may arise as to the advantages or otherwise of having converted the bridges to which the machinery for regulating the supply is attached, into roads of communication for the public, especially in cases where such roads are the high lines of the Country, passed by crowds of people, and open day and night to the constant passage of Mail Carts and trains of waggons. Before closing this Section, therefore, I may in adverting to the causes which have led to this arrangement, point out that it was obviously one of economy, and that it has been practised elsewhere although in cases where the amount of traffic was comparatively small. The Kulsea Regulator on the Eastern Dummoodah Canal

Canal lies on the high road between the Town of Saharunpoor and the Kinki pass which is the main western gate through the Sewaliks into the Himalayas; it connects Saharunpoor also with the Towns of Behut and Rajpoor two of the Chief police Stations of the District. The traffic over this Bridge although less than that which passes over the Ganges Canal at Bridges similarly situated is considerable; yet the only inconvenience that has been experienced is in the petty pilfering of Iron from the sleepers and windlass apparatus, the more probable objections of the working of the Machinery being interfered with by the constant passage of Men and Cattle across the Roadway have not been realized. On the Ganges Canal works including the Two regulators of the 1st Section of this Chapter, there are six points at which Bridges having to which Machinery for regulating the supply is used, are used for the public convenience; of these the Myapoor Regulator and those crossing the Terminal lines at Nanoor, are the most prominently connected with extensive Through fares.

The Myapoor Bridge is the main connecting link between the Towns of Burdwan and Kunkhil, and during the Annual fairs is literally not only crowded with people, but is traversed by a continued stream of equipages. At this point

point it would have been hardly possible, laying economy out of the question, to have had a separate bridge for the convenience of the Public; the Shutter arrange=ments, although liable to be called into requisition at any moment, are chiefly for the pur=pose of keeping the floods of the Ganges River out of the Canal Channel, and are, consequently, ~~most in use~~ during the rainy months, that is to say for the 4½ months from June to September the only cause for their being used at other periods of the year, would be on the occasion of floods occur=ring during the Cold weather and at unseasonable periods during the remaining months. accidents to the Canal works + might lead to either a partial or general working of the Mya=-poor gate apparatus; but as a general rule the active period ~~to which it is put into~~ its use is during the 4½ months above spe=cified. The great concourse of people takes place during the ~~period~~ time of the annual fair, ~~held at~~ ~~time~~ when the probabilities of the gates being called into re=quisition are exceedingly small. The Bridge Roadway being 37'.9" in width is sufficient at all other times to give free room for the working of the gates, as well as for the passage of the public. it was considered, therefore, that there would have been no object in separating the regulating apparatus from the main thorough=fare

-fare at this particular point, and as the Kumkhul Bridge which is situated 2 miles South of the Regulator has been provided for the ~~practice~~ additional convenience of the Towns of Kumkhul and Sundwar, that further means of cross com-=munication were unnecessary I do not anticipate the slight-=est inconvenience either to the works or to the community from the arrangements which have been adopted in ~~the~~ this case ~~of the Nyapoor Regulator~~.-

Again, at the Nanoor Fork where the whole traffic between Caunpoor and Alligunk is car-=ried over the Regulators attached to the heads of the Two terminal lines, I may observe, that the use of the Regulating appara-=tus will never be so constant as to cause interruption either to the works or to the community, that as the Bridge Roadway is made of increased width, and the roads themselves are laid out so as to give the utmost facility of approach, there appears to be no reason why a separate bridge should have been built at a cost of 15,000 ~~Cos Rs~~, for the convenience of the Grand Trunk road, whilst the present Regulators which must have been in close proximity were limited to Canal purposes. At any rate considered as an experiment the plan carried out has the merit of economy; with the advantage (supposing ~~that~~ the Road authorities find by experience that the communica-=tion offered by the present line is

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alter

is an inconvenient one) of leav-
-ing the Question of building a
2nd Bridge for after consideration

In the four other cases
where Regulating Bridges come
in contact with high roads, the
absence of extensive thoroughfare
renders them of no inconvenience

The above remarks will
shew that doubts have existed
in my own mind as to the
propriety of turning these works
to the double purpose to which
they have been converted, and
there can be no ~~doubt~~ question that econ-
-omy had very great weight in
influencing the determination

In closing this section
of the Chapter, it merely remains
to point out the views ~~which~~ I
hold with regard to the Estab-
-lishment which ought to be
maintained for the working of
the Regulators at the heads of
Branches. I am inclined to
place this on the same footing
as that of the Regulators in the
Ganges Khadir described in
Section I, giving to the Jemadars
the same duties, and making
them responsible for the main-
-tenance of the Banks, roadways
and Esplanades within a defined
limit of their post. - Under this
view of the Question, and con-
-sidering that the maximum
number of gates at each branch
head, which may be required to
be worked at one time, are those
over the largest Channel, I would
define the Establishment thus:

	No: of Gates			
	Main	Branch		
1 Sutligurh Head	9	4	4 Gangs of 10 Men each	= 40
2 Bolundshuhur do	8	3	4 do of do	= 40
3 Koel do	6	3	3 do of do	= 30
4 Manoon do	5	5	2 do of do	= 20

this provides 4 Men to each gate giving in the three first cases a surplus which is desirable from the Magnitude of the volume of water, as well as for maintain=ing the Gangs on an equal foot=ing - Each Gang of 10 Men would have a Mate, and be subjected to the same disciplines and en=trusted with the same duties as are laid down for the Es=tablishments attached to the Myapoor and Dhunowri Regu=lations: and as at those works the Director's Rules and Regulations printed in English, Hindi and Oordoo, should be hung up in the public buildings, and posted in conspicuous situations

III - Escapes. -

The Ganges Khadir on its whole length from Myapoor to Roorkee, has no works which can be specifically classed un=der the above denomination, I have before noted that the Dams at Myapoor and Dhun=owri although to all intents and purposes capable of afford=ing Escape, and therefore used for this purpose whenever re=quired, come more distinctly under the classification of Drainage works in the Chapter devoted to which they have been described. On all occasions how=ever where the supply passing over the Solani aqueduct requires modification, either the sluices of the Myapoor or Dhunowri Dam are put in requisition. -

It

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It is on the high land of the Country, and after the water has passed the Khadir of the Ganges, that the works which are placed under this Section begin to develope themselves. It will be understood that from various causes, especially those relating to local Irrigation, and frequently to a somewhat capricious and irregular abstraction of the water from the main Channel, the equilibrium which theoretically exists between the supply and the Capacity of Channel at given parts, must be liable to disturbance. For instance, theoretically the abstraction per Mile for the purposes of Irrigation is uniformly (on a line of 360 miles) equal to 8 feet per Mile, on which assumption the size of the Channel is excavated. It is perfectly clear that on such a long line, extending from the foot of the mountains where the climate is moist, to regions where hygrometrically speaking the climate is entirely changed, the demands upon the supply must not only vary with regard to climate and soil, but must be perpetually dependant on local rain falls, the extent of which in these Provinces is very remarkable. These irregularities, necessarily attendant on local causes must be met by efficient remedies, and in this case by providing outlets at stated distances along the line of Channel, so that in the event of a superabundant supply which is observed by a water gauge established for

for the purpose, the extra waters may be passed off and allowed to escape into Side Channels. I have before alluded to the Raj=bulhs Heads and their Channels, as the Safety Valves for maintaining an equilibrium under excess of water, they will undoubtedly act in this respect most beneficially. the works, however, which I am now describing are specifically for the purpose of regulating the Channel Supply, and for maintaining it at such a depth as may be most convenient to the works, or most useful to the Cultivators. In designing these works I have laid down the following rules for my guidance, and although from local causes they have not always been strictly attended to, they have been followed to an extent sufficient to meet the purposes which are contemplated:-

1st With reference to Position I have limited the distance between the Escapes to 40 miles, considering that by adapting their capacity for outlet to the volume of water contained in the 40 miles of Channel to which they are intended to provide the means of escape, the facilities for Regulation will be ample.-

2nd In the Sandy tracts which constitute the Elevated region lying above the Ganges and West Kullo Nuddi, to multiply the number of Escapes rather than to increase their waterways; to encounter the difficulties of contending with large volumes of water in detail, rather than in mass; and to facilitate

and

and ease off the passage of the escape water by length of Channel as well as by artificial protective expedients.—

3rdly To fix the sites of all escapes in such a position that there may be a plunge into the bed of the re=ceiving Channel, and that the high water mark of the latter may in no case interfere with the free discharge of the water from the Canal.—

4thly To make the Escape build=ings a component part of other works, or, should this not be pos=sible, to place them in such close proximity to Bridges and Chokies, that they may be easily accessible and properly looked after.—

5thly Independently of original excavation which is devised simply on economical principles; that the Escape Channel when perfected shall in addition to the initial slope of 12 Inches from the bed of the main Channel which is given to the tail of the Escape head, have a slope of bed equal to 1·5 feet per mile, the superfluous slope being overcome by permanent works in Masonry, adapted to the particular circumstances under which the Escape Channel is situated.—

From Roorkee, therefore, downwards the sites of Escapes for the relief of the Canal Channel have been determined on the above principles, unless there have been reasons which will be fully explained, for their having been departed from.—

It

It will be advisable for the sake of distinctness to divide the Escapes under different Heads

A Those on the Main Trunk between Roorkee and Nanoor

B On the Cawnpoor Terminal Line

C On the Etawah &c

commencing with A we have on the Main Trunk

1.	The Khatowli Escape	62	Miles
2	Mahomed Abad's &c	69	&c
3	Jamni Khoord &c	87	&c
4	Moondakhera &c	141	&c
5	Kasimpoor &c	166	&c

Five different works, situated at distances from the Myapoor Regulator as shewn above.—

Now, the three leading items viz: the Escapes at Khutowli, Mahomed Abad, and Jamni Khoord, are for the relief of the Channel at points where from the large volume of water that it has to carry, and from the nature of the soil through which it is conducted, most especial care is required. These 3 Escapes may be considered under the 2nd Head of my rules for guidance, as two outlets divided into three separate lines. Their width of waterway, in the aggregate is equal to 180 feet, and as separate works, they provide a discharge of 60 feet in width—each work consists of 10 bays or Sluices of 6 feet in width each; and they each throw their water into the Valley of the West Kalli Nuddi under circumstances peculiarly favorable with reference to declivity of Channel, although from the Sandy nature of the soil through which the bed is excavated,

and

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and the amount of fall, to be overcome by high protection works as necessary, the completion of these Escape lines will be a heavy item in the expenditure.—

Taking these 3 Escapes in the order of their precedence we first pass in review.

No 1. The Khutowli Escape

This building is situated on the right bank and on the down Stream side of the Khutowli bridge or that on the high road between Saharunpoor and Meerut. The axis of the Bridge and Escape are separated by a distance of 550 feet.—

The west Kali Nuddi with which the Canal is connected at this point by an excavated Chan- at its head, decreasing to 20 feet at its tail, =nel 60 feet in width lies at a dis- =tance of $3\frac{3}{8}$ miles.— Advantage was taken of a ravine or tributary which extended inland for some distance to reduce the length of digging by leading the line to its head. The map and section of this portion of the work are shewn in the following diagram

(Here insert Diag: XCIII)

The total fall from the level of the Canal to that of the west Kalli

Kalli Nuddi is 29·21 feet on a length of 20000 feet or 3 miles 6 furlongs and 290 feet, the total fall per mile being 7·71 feet. To have completed this line with properly regulated slopes, and with the necessary works for disposing of the superfluous fall, would have been a work of considerable time and labor, and it would have occupied the attention of the Supervising Establishment, in a way that would have led to interruption to the ~~progress~~ works of the Main Canal line upon which more immediate progress was indispensable. I therefore determined after clearing out the Channel so as to admit of a free passage for the escape of water, to postpone the executing of the permanent works for the correction of the slopes, until the current by acting on the bed, had by its natural retrogressive excavations, given us fixed points for establishing the masonry descents. The saving in expense by thus permitting nature to perform the duties which we must otherwise have done by labor, is very great; and from the ~~nature~~ character of the work, and ~~from~~ our ability to regulate the water passing along the Channel, or even stop it altogether, there could be no fear of accidents or disarrangement; the plan under such circumstances was quite a legitimate one, and I have practised it universally in all the Escape Channels connected with the Ganges Canal works.

Instead, therefore, of carrying the

the excavations on an uniform slope of 1½ foot per mile, until the bed level struck upon the slope of the valley: the above slope was given to the leading mile of its course only, or up to a point where the Channel is crossed by the main Right Rej=-bulva to which a bridge of cross communication is attached:- from this point the excavation was carried on a dead level, by which 1½ foot in depth per mile was saved. The Bridge attached to the Rejbu=-lva, has at its downstream side an overfall of 8 feet in perpendicu=-lar depth, constructed in the usual form, protected by flank and tail defences, and in every way ready to meet the action of retrogression. It will be understood that by the above anangements, out of the total fall of 29·21 feet from the Canal bed to that of the River, we only dispose of 1 foot, the amount of tail fall to the Es=-cape head, 1½ foot to the slope for one mile of Escape, and 8 feet for the Masonry descent, or a total of 10½ feet: The remaining slope having to be regulated by an amount of Masonry descent equal to 15 feet, the balance being disposed of in the slope of the earthen Chan=-nel. With the profile of the country before us, and knowing the slopes upon which it is our intention to regulate the bed of the Escape Channel, it is obvious that the Engineer can determine the precise position in which, when the current has made its own excavations, the

additional

additional Masonry descents will have to be built; he, therefore, has collected on the spot material sufficient to execute the work with the greatest promptness, so as to preclude all chance of the works which are situated in the rear being injured. —

I have in the above section noted the precise points at which the falls may be built hereafter, placing as great a distance between them as possible: the most economical material to use in the construction of these works will be masonry; by building them of the best + Brick and Kunkur work in the first instance, repair will be saved hereafter, as their position detached altogether from the main line of works and consequently of patrol, will render them liable to less supervision than would otherwise take place. — I need hardly dwell on the necessity of periodical examinations of works of this sort both by the Executive Officer and the Director of the works —

The disposition of Slopes and works on the Khantowli Escape, with the necessary data on which they were arranged, may be thus explained. —

Length of Channel from Main Canal to the West Kalli Nuddi		20000 feet
Total Fall from bed of Canal to bed of River		29·21 feet
Slope at 1·5 feet per Mile	5·68	
Tail Slope of Escape Nuddi	1·00	6·68 "
Balance to be disposed of in Masonry Falls		22·53 feet
Of this in Rajbuha Bridge	8·0	
At 2 points intermediate between the Rajbuha Head and the West Kalli Nuddi 2 Falls of 7½ feet each	15·0	
		23·00

It is desirable that the masonry descents should be placed at as great a distance from each other as possible so as to prevent the accumulation of velocity on the heads; and to secure this, the above rule of placing the falls equidistantly is probably the best; in practice, however, the falls are in all cases connected with Bridges, so that their position on the Escape, depends in a great measure on the high roads of the Country. In all cases where the depth of Channel is sufficient I have designed the waterways of these Bridges in one bay of 50 feet width.

The total cost of the Excavation on the above work was Cos Rs 20805.8.5 at a rate equal to Cos Rs 1..10..5·6 per 1000 Cubic feet.

The Masonry Head, consists of 10 Openings of 6 feet in width each, their height from flooring to the soffit of the arch being 8½ feet; the flooring is raised 2 feet above the Canal bed in gradations depending on the working of the gates and sleepers. The transverse width of the flooring is equal to 64 feet, 40 of which form the tail which is laid on a slope (inclining down stream) of 1 foot from the level of the Canal bed The flanks of this work are protected by Masonry Revetments and the usual guards of piling and rubble work, with which the floorings are also covered and protected from the wear and tear of the current on its approach and departure, by bond work aprons

In

In consequence of the magnitude of the Canal Embankments at Khutowki, and the elevation of their upper esplanade which is 20 feet above the Canal bed, the apparatus for opening and shutting the Sluices has been covered by a line of building, the roof of which corresponds with the higher levels and, therefore, acts as a Roadway, without interrupting the communication on the Bank. The supports for the windlasses, which consist of upright timbers placed in the form of a cross, act also as supports to the roof, and give great additional strength to the building: it will be seen by the plan, plate XXXVII that the chains attached run over an upper roller, by which the whole water way is relieved, by the gate being drawn up through the slit made in the flooring, and raised as high as the roof; the design is of the simplest description, it is exceedingly strong, and from its being protected from the weather, and from disturbances arising from other causes, it is hoped that the working will be very efficient.—

This work is built with a combination of old and new brick, with Cement consisting of the following ingredients

2 Parts of Earth Lime
1 " Pozzolee

The totals quantity of Material used is equal to

4.33,867 Bricks of various sizes
19283 Cubic Feet of Lime (Earth)
9641 " of Pozzolee

and the rates at which the work was executed were as follows

Masonry	Cos Rs	13..7..11 pr 100 Cubft
Plaster	"	2..3..7 pr 100 Sqft

This Escape was begun by Lieut Fraser of the Engineers, and completed by Mr Read, under whom the adjustments of the machinery has been managed Its total cost was, excluding Regulating Apparatus, Cos Rs 11778..2.9

No 2. Mahomed Aboo's Escape

The building at the head with the exception of the covered in accommodation for the Machinery, and the superstructure appended thereunto, is the same as at Khutowli; the bays however are 13 feet in height from the flooring to the soffit of the arch.. The sluice gates which are of the same description as those at Khutowli are worked by windlasses resting in the plain bitt heads common to the Canal works in these Provinces. They are protected by a 2nd Class Chokie which is in close proximity to the work.

The site of Mahomed Aboo's Escape is on the right bank of the Canal between the 69th and 70th mile of its course from the Myapoor Regulator.. It is the most awkwardly situated of the whole of the Canal works, being separated by a considerable distance from bridges of cross

cross communication. From being on the opposite side of the Canal to that upon which the high road runs, access to it can only be gained by crossing the Canal either at the Salawun or at the Attema Bridges, from the former it is 13265 feet distant, and from the latter 7960 feet. — It would be desirable, perhaps, to maintain an open road along the right bank of the Canal as well as on the left, between the Salawun Falls and the Attuma Bridge, by which means free access would be given to Mahomed Abou's Escape, and the communication with this building, which is now rather awkward, would by these means be perfectly facilitated. —

The Channel as its name indicates is a portion of the ancient Canal dug by Mahomed Abou Khan — as will be seen by the plan in the following diagram, we have taken possession of the lowest of two lines which appear to have been formerly used as heads for the Canal; the levels of our Escape being carried in a counter direction towards the River, when it joins under Fureedpoor —

(Here insert Diag XCIV)

Diag missing

The disposition of slopes and works which are required for this

this line of Escape will be explained by the following.-

Distance from the Canal Channel to the West Kalli Nadi		miles - feet 7 .. 311
Total fall from bed of Canal to bed of River		23·93 f/t
Required Slope From the tail of Escape Head Channel Slope on 7 Miles @ 1·5 feet per mile =	1·00 10·50	11·5
Balance - Superfluous Slope		12·43 f/t

To which it would be sufficient to give 2 descents of 6 feet each, ~~which would~~ admitting of 2 bridges of cross communication, to one of which the line of Right main Rajbaha would be attached.- I have, under the head of the Khutowli Escape, stated that in all cases where the depth of Excavated Channel will admit of it, I have designed the waterways of these bridges and falls in One bay of 50 feet in width, with a Segmental Arch of 60° this in Round numbers gives a versed Sine or rise to the arch of 7 feet, which with the height of pier and thickness of Arch and Superstructure connected with a Superpassage Channel for the Rajbaha, necessarily limits this dimension of arch to certain localities, where the depth of digging is great and where the bed of the Rajbaha lies on a high level.- By doubling the number of bays and reducing the width of each to 25 feet, we diminish the versed Sine to 3½ feet, and reduce it to one half of that of the large arch, and by these means are enabled to reduce the

the height of the superstructure and to adapt it to the section of the excavated Channel. I would in no case reduce the waterways of the bridges below 50 feet in width, as independently of the escape water from the Canal the Channel will hardly pass through so long a tract without receiving in its course a considerable quantity of country drainage.—

The design upon which Mahomed Abbo's Channel has been excavated, is the same as that practised at Khutowli— The leading mile has been excavated on a slope of 1·5 foot per mile, from which point it is carried on, on one uniform level, Nature being allowed to work her own progress in retrogression of wear, and the Engineer having to meet the retrogression by the Establishment of permanent works— Here, as at Khutowli, the leading Bridge with its fall, is attached to the main Rajbaha which is at the time that I am now writing in the course of ~~progress~~ construction— The natural wear ~~upon~~ upon the bed, therefore, will take place between the west Kalli Nudi and the down Stream side of this bridge, precisely as is the case at Khutowli; in that instance, however, 2 intermediate falls have to be constructed, in the present there is only One.—

The Capacity of Channel as excavated is reduced to the most economical limits, being in rectangle 60 feet in width on the 1st, 40 on the 2nd, and 20 feet in

in width on the remaining miles of its length, the side slopes being at an angle of 45°

The Cost of this Excavation was Cos Rs 34807.6.8 at a rate per 1000 Cubic feet equal to 1.9.6·8

The Headwork is constructed of Kunkur and brick masonry, the disposition of the material being the same as that universally adopted in this Div.n of the Works where Kunkur is procurable - Kunkur being used in the floorings and most massive parts, and brick Elsewhere.

The proportions of material used in Cement are as follows:-

2 Parts of Earth Line
1 Part of Sookee

The quantity of material expended ~~in the Works~~ and the rates at which the different species of work ~~was~~ were executed will be seen by the following Table.-

Rates of work
Masonry Rs 12.8.6 per 100 Cubic Feet
Plaster . 3.0.3 per 100 Superficial Feet
Materials expended
425640 Bricks of various Sizes
18918 Cubic Feet Earth Lime
9459 — as — Sookee

Mahomed Aboo's Escape was begun and completed by Mr Read the Executive Officer of the 2nd Division of the Works. Its cost was, excluding the Cost of Regulating Appurtenances Cos Rs 10487. 11. 7

No 3 Sanni Khoord Escape

This as the third of the series of Escapes attached to the upper

upper portion of the Main Trunk on its passing over the high land of the Doab, is built precisely on the same plan and with the same extent of waterways, sluice arrange=ments, &c as has been explained at the others; it corresponds however with Mahomed Abous Escape in regard to want of cover for the windlass apparatus, and absence of superstructure connected with it. The height of the sluice open=ings from the flooring to the soffit of the arches is equal to 11½ feet, and their Regulating apparatus is precisely similar to that at Mahomed Abou's outlet

The Head is situated on the right bank between the 87th and 88th mile, and at a distance of 1130 feet from the upstream side of the Damri Khoord Bridge; a 2nd Class Choki is built inter=mediately between the Bridge and the Escape, for the purpose of affording protection to the latter work, and of keeping the Establishment on the spot.—

The excavated Channel is similar to that before described, and its design with reference to natural abrasion is the same

The Map of the Country with the Profile of the line upon which the excavation has been carried are shewn in the following diag:

Dig XCV.

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The Escape Channel joins the Nindum River at a point in its course 20 Miles below the junction of the West Kalli Nudi; at this point the bed of the Nindum is 38·06 feet below the bed of the Canal, a difference of level which will lead to works of a more extended description than those before described at the Khutowli and Mahomed Aboo's Escapes.—

The disposition of works depending on this excess of Slope will be as follows:—

Distance from the Canal to the Nindum		M. 3 F. 7 = 5.3. 445 say 5 Miles
Total fall from the bed of the Canal to the bed of the Nindum River		38·06 feet
Required Slope for the tail of Escape head	1·0	
Slope of Channel 1·5 for 1 Mile	7·5	8·50.
Balance superfluous Slope		29·56 feet

To overcome which 4 falls of 7½ feet will be required. Of these 4 falls the leading one, or that nearest to the Canal would be adapted to the passage of the Main Right Rajbaha, and the remaining 3 would occupy positions at intermediate distances, providing the means of cross communication by Bridges.—

The ~~Cut in~~ Excavation Channel ~~is being done~~ in progress at a rate of Rs 1.. 8.. 0 per 1000 Cubic feet.—

The Head work is as in the case of Mahomed Aboo's Escape built of Kunkur and brick, the former being confined to the foundations and the massive parts of the Structure.—

The proportions of material used in the Cement are as follows

-lows.-

2 Parts of Earth Linie
1 — Sp Dookie

The total Quantity of Material expended, and the rates charged for the building, are exhibited in the following Table.-

521010 Bricks of various sizes
23156 Cubic feet Sp Earth Linie
11578 — do — of Dookie

Masonry including Plaster	1/4	7	11·8	pr 100 Cubic feet

P01

The Damm Khoord Escape Head and Excavated Channel were commenced and are being Completed under the supervision of Mr Read, and cost. exclusive of the Regulating Apparatus.

Cos Rs 13204 " 3 " 7

The above gives a general outline of the 3 Escapes to which I have before alluded, as combining in themselves a relief to the Main Channel in its passage through the early and Sandy districts of the high land of the Doab - It will be understood from what I have before said, that the works as at present constructed consist of an Escape head attached to the Canal Embankments, and a passage for the Right Rajbuha the latter being connected with a Bridge of Communication and with a Masonry fall for the purpose of overcoming superfluous slope.- The Channels of Escape have also been excavated so as to admit of an open passage for the

the water, and to give free scope to the objects for which they were designed - The works in all three cases are completed as far down the Channel as the Bridge over which the Rajbuha passes, and to which is appended the 1st ½ Masonry descent, beyond this point operations for the present have ceased; the completion of the remaining Overfalls, and the adjustment of the remaining slopes, being left until the activity of the Current has cleared the Channel sufficiently to admit of it.—

In recapitulating the works attached to the three Escapes above described, the following Table will shew the work that has been completed, and that which remains to be done as opportunity offers

	Total required		Built in progress		To be built hereafter	
	Rear	Falls	Rear	Falls	Rear	Falls
Khutowli Escape	1	3	1	1	-	2
Mahomed Aboo's do	1	2	1	1	"	1
Danni Khoord do	1	4	1	1	"	3
	11½	2	2	1½	3	3

There are, consequently 6 Masonry descents remaining to be built after the Escape Channels have been brought into use; of these 2 at Khutowli have a fall of 7½ feet each, that at Mahomed Aboo's Escape of 6 feet, and finally 3 at the Danni Khoord Escape equal to 7½ feet each; the full waterway being 50 feet in width, either in one or two bays, as may be most convenient to the particular site on which the work is to be built. The plans and sections

of

of these Overfalls are shewn in Plate XLVII of the Atlas.—

No 41.— Moondakhera Escape

Passing by the Head of the Bolundshuhur Branch at the 110th Mile which may be considered as capable on emergencies of performing the duties of an Escape, we arrive at the Moonda Khera outlet, lying at the 141st Mile, and at the head of the rapid descent which takes place in the Canal levels at the lower extremity of the main Trunk.—

The Moonda Khera, and its neighbour the Kasimpoor Escape are to the lower, what the three Escapes before described are to the upper tract of the main Canal in its passage over the high land of the Country.—

The influence that these two works exert upon the regulation of the supply in the Terminal lines into which the main Trunk is separated at Nanoor has been elsewhere adverted to, that now under description I may repeat, provides the means of relieving the Canal on occasions when the Bolundshuhur Branch is thrown out of use, and its water is turned into the main Trunk, which it also relieves from a large body of water at a point before it reaches the lower levels in the neighborhood of Alleegurh.

The Moondakhera Escape gives facilities also for repairs to the masonry descents and works connected with them, which lie on ~~the~~ its down stream side.—

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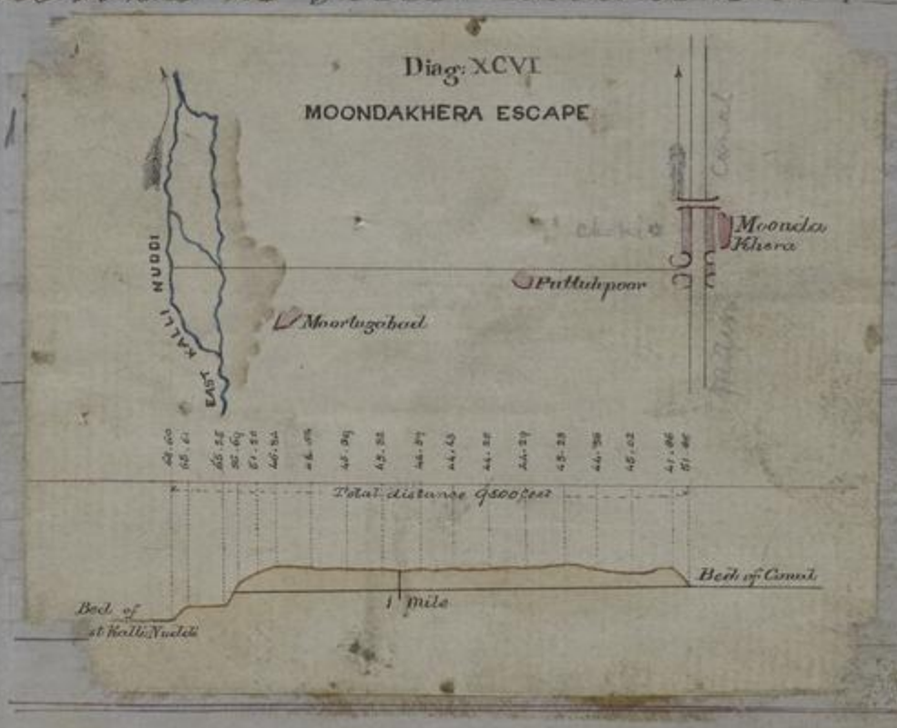
At the point of the Canal where this work is situated, the alignement has deserted the valley of the Jumna, and its dependent tributaries, and is in close contact with the East Kalli Nuddi, the River which provides drainage to the most Northerly flat of the Ganges for a distance of 10 miles in the neighborhood of Moonda Khera the East Kalli Nuddi and the Canal run in close proximity, separated from each other by a tract of country not exceeding 2½ miles, and at a point near the village of Mumeen about ¼ mile in width. —

The site at Moondakhera was selected as being convenient from its proximity to the site of a 1st Class Choki Post, and to the country lying between it and the River being well adapted for the Excavated Channel. —

The following Plan and Profile will with the figured description of the disposition of slopes and works offer a fair explanation of the value of this Escape: it being understood that the arrangement before described of leaving the current to act upon the bed under prescribed limits is still continued. —

Diag. XCVI



Distance from the Main Canal to the bed of the East Kalli Nuddi		9500 feet
Total fall from bed of Canal to bed of East Kalli Nuddi		16·74 feet
Tail slope for Escape head	1·00	
Slope of Channel 1·5 p^r mile	2·69	3·69
Balance - Superfluous Fall		13·05 feet

To which two masonry descents each with a drop of 6½ feet would be required. The leading descent which will, I imagine, be built near the village of Futtipoor will have the Superpassage Channel of the Main left Rajbuha attached to it - the second fall will be established near the village of Mootazabad near the crest of the high land on its descent into the Valley of the River. A width of water very equal to 30 feet ought to be given to the bridges which cross the Escape The Channel has been excavated on a width of 50 feet and a bed slope of 1·25 per mile. The soil is of a tenacious quality, and as such is very superior to that with which the Upper Escape was connected. —

The Head of this line of Escape forms a component part of an extensive series of works connected with the Moondakhera Bridge, its axis is separated from that of the Bridge by a distance of 4334½ feet; it lies on the left Bank and is joined to the Bridge itself by a line of Ghats or Steps, which meet the face of the Bridge in an Ogee curve; Similar Ghats and works of protection to the right and opposite side of the Canal, are also built in correspondence with those on the left. —

The

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The Bridge which lies at a distance of 1½ Miles or thereabouts from the Town of Khooja, acts as the main line of communica-tion between that Town and the Country on the left bank of the East Kulli Nuddi. Between the Bridge and the Escape Head, and in the centre of an Esplanade is a 1st Class Class Chokie building; the works are considerable in ex-tents, and will I think be found to be conveniently situated.—

The design of the Head differs in detail from that of the works before described. As built on the Left or Road side of the Canal, and consequently connected with the towing path, it was necessary to maintain an unbroken passage along the berm. In this region of the works, moreover, the quantity of Earth excavated from the Channel did not necessitate the raising of the embankments to an immoderate height, leading to the deformity which exists more or less on the whole tract extending from Moyapoor to the 110th Mile. At Moonda Khera the Sections both in berms and esplanades is equably formed, and the Earth-work is altogether of a more com-pact description, and of a more uniform character than it is in the upper districts. The above ad-vantages added to the Towing path arangements have as I said before led to modifications of the plan before described. The Sluices 10 in number and each of them 6 feet in width are arched over, both on the full width of the

the berm and Roadway, so that a free passage is open on both the former being on a level with the Earthen berm, and consequently depressed to an extent of 2 feet below that of the road-way.—

The sluice Gates are worked by windlasses and the usual apparatus, through slits or apertures situated between the berm and the bank, on the Canal side The Cutwaters also which lie at the mouths of the sluices are fitted with grooves for sleeper planks The tail flooring, or that which lies on the downstream side and towards the Escape channel is 40 feet in length, on the full width of the work; the flanks on the right and left of the Tail are raised to a height of 12 feet, so as to admit of the upper Esplanades being retained on equal levels— A plan of this work is given in Plate XXXVIII of the atlas.—

The Masonry with the exception of Archwork and finishing, consists entirely of Block Kunkur, the Cement which was used being of the following proportions.—

1 part Kunkur Lime, to
1/20th of White Stone Lime

The total quantity of Materials, and the Rates at which the work was executed are shewn in the following Table.— The Moonda Khera Escape Head ~~being~~ is a component part of the Bridge and Shuts at that Head, ~~and in the Cost of which it is included~~ ~~Cost Cost of, and Materials used on the work, is prevented; but~~ the following

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The work was begun and completed by Mr Philips Contr. and Cost however as follows are the rates at which it has been executed.—

Inch masonry	15	..	..	per 100 Cubic feet
Other do	10	..	11	per do
Plastering	2	5	8	per 100 Sup. feet
Metalling	2	..	.	per do
Bitt heads	15	..	.	each
Windlasses	10	.	.	"
Earthwork of Escape Channel	1	4	..	per 1000 Cubic feet

No 5. Kasimpoor Escape

This work is in all respects similar to that at Moonda Khera it has the same extent of water way, and its situation relatively to the Kasimpoor Bridge is in all its details connected with the Bhuts Choki accommodations, &c similar.

The Escape is on the left bank at the 166th Mile of the course of the Main Canal, and immediately below the Falls at Pulra and Sirra its position is intermediate on the line extending from the Sirra Falls to the Nanoor Regulators.

The especial duties which the Kasimpoor Escape is intended to perform, are 1st, the relief of the Canal from excess of water arising from the supply of the Koel Branch head being thrown into the Canal Channel. 2nd, The Regulation of the supply into the Terminal lines into which the main Trunk is divided at Nanoor. Connected with the Moonda Khera Escape, it perfects the means of relieving the Canal Channel from excess of water in the lower regions of the main Trunk.—

The following Diagram shews the line of Country which

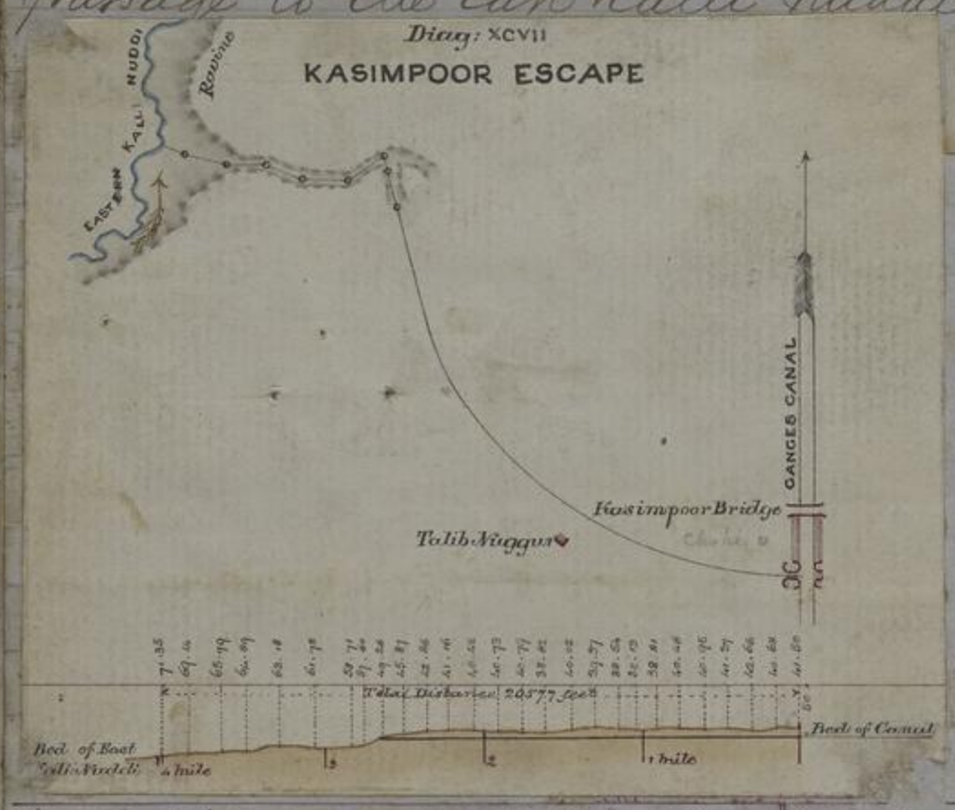
is

is crossed by the Escape in its passage to the East Kalli Nuddi

B.83

XVII

XCVII



Distance from main Canal to line of East Kalli Nuddi		20577 Feet
Total Fall from Bed of Canal to bed of East Kalli Nuddi		21·35 feet
Tail Slope for Escape Head	1·00	
Slope of Channel @ 1·5 feet per mile	6·00	7·00
Balance Superfluous Slope	——	14·35 feet

This will be disposed of in the usual way, the leading fall being connected with a Supersp-sage for the left Main Reybuha.- The remaining descents will be constructed hereafter, when the effects of retrogression of levels render such works necessary. The soil, at least that part of it which is connected with the high land is firm and tenacious; and I imagine alone exists in the valley of the East Kalli Nuddi

The Channel has been excavated on a width of rectangle equal to 50 feet; the banks have been laid out at 1·25 feet per mile.-

The Kasimpoor Escape is proposed to be attached to the Divisional charge of the Officer who holds the Terminal lines It will constitute the Head of his division, and will give him the power of regulating the supply of

of water required for his irrigation.
The Method of construction
of the Kasimpoor Escape Head
and the description of material
used, are the same here as at
Moondu Khera:- The proportions
of ingredients used in the Cement
being as follows.—

8

1 Part Kunkur Lime to
1/20th of White Stone Lime

~~The total quantity of Material~~
~~and the rates of the work, are~~
~~shewn in the following Table.—~~
~~The Kasimpoor Escape Head~~
~~is (as at Moondakhera)~~ a Component Part of the
Bridge, Shuts &c. at that place
~~in the Estimate upon which it is included~~
~~the Estimated cost~~
~~of Land Materials used on this~~
~~The work was commenced and~~
~~completed by Mr Philips Volk~~
~~and Co.~~

~~Particular notice is given.~~
~~But~~ the rates of execution were
as follows.

Arch Masonry	15	..	.	per 100 Cubic feet
Other do	10	1	3	per do
Plastering	2	11	11½	per 100 Square feet
Metalling	2	1	6	per do
Pile heads	15	-	.	each
Windlasses	10	-	.	do
Earthwork of Escape Channel	1	5	.	per 1000 Cub. feet

The work was commenced and
completed by Mr Philips Volk.—
The five Escapes above described
embrace the whole of the works
which are specifically designed
for regulating the Irrigation sup-
=ply on the tract from Roorkee
to Narsoon. Their disposition
on the line of Canal is in some
degree connected with the heads
of the Branches, from which they
derive in all cases very material
assistance, and a support which
as being mutual, adds considera-
=bly

=bly to the efficiency of both. The command that these works have over the Rivers into which they discharge their surplus water is in all cases a security against interruption at any season of the year. —

B. The Escapes on the Cawnpoor Terminal Line. —

Under this section are included all the works for regulating the supply between the Nanoora Regulating Head and the works at Dubowli, the latter being included in the list of Terminal works appended to the descent into the Ganges at Cawnpoor.

It will be observed by the map and the position in which the Cawnpoor line of Canal is placed with reference to the Rivers on its right and left, that the facilities for disposing of its escape water are by no means so good as those which attended upon the Main Trunk in its passage to Nanoora. The East Kalli Nudi by taking a wide departure from the bearing upon which the Canal runs, is at too great a distance to be made conveniently available, whilst an intervening River, the Elsun, which rises on the left almost immediately after the Canal leaves Nanoora separates the Canal from the East Kalli Nudi entirely. On the right, the line of Canal is accompanied on the greater part of its course by the Rinde, and the

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Datum

the Pandoo Rivers, which like the Essun, continue for many miles in the early part of their course, in a shallow ~~and moderately de-~~ ~~pressed~~ bed, ill adapted both from slope and capacity of Channel for affording relief to the Canal supply.—

Advantage to a limited extent has been taken of the East Kulli Nuddi, and ~~as~~ whilst avoiding the Channels of the Rivers, the Essun and the Pandoo as far as it was possible, in those parts of their courses which were most especially open to the inconvenience above referred to; we have used them at more advanced points where the elements required for efficient Canal Escape were comparatively speaking of a higher order.—

The Escapes on the Cumpoor Terminal line are as follows

1. The Ginnowli Escape at the 9th mile
2. Nugaree at 49th "
3. Tireea at 87th "
4. Kukwan at 135th "

The Dubowli Escape which is situated at the 165th mile, and is the head of the Cumpoor Terminal works, is as I have before said included in the Chapter devoted to these works; its existence however may be noted here, as a work which perfects the chain of Escapes on the Terminal line connected with the Ganges.—

1. The Ginnowli Escape Head

The Channel with which this work is connected is more specifically

Specifically for the purposes of drainage them for regulating supply; its object is to provide relief to certain low tracts of land on the left of the Canal bank, which were previously to the excavation of the Canal, directly connected with the drainage of the Rind, but which have by the interposition of Embankments been cut off from their natural watershed. By a series of cuts and works which have been described elsewhere, the whole of the intercepted drainage is brought to bear upon an excavated Channel which commences at a point above the Grimonli bridge, and from thence is carried on a straight line to the valley of the Cut-Kalli Nuddi.

The necessity for connecting the low lands in this neighborhood with the River above mentioned, and the convenience to the works of combining with the Channel excavated for the purpose an Escape ~~Head~~ from the Canal, led to the erection of the Grimonli Escape Head. During the dry season the Channel is always available for Canal regulating purposes; during the rains an increased and regular supply from the Canal might maintain a flow of water down the Cut, which would be very advantageous for the purposes of scour, and for ridding the Channel of impediments.

The Channel here, as in the case of all those that have been excavated for the purposes of Escape, is ~~dis~~ dependent for perfect efficiency on the wear and tear of the Cement

Here

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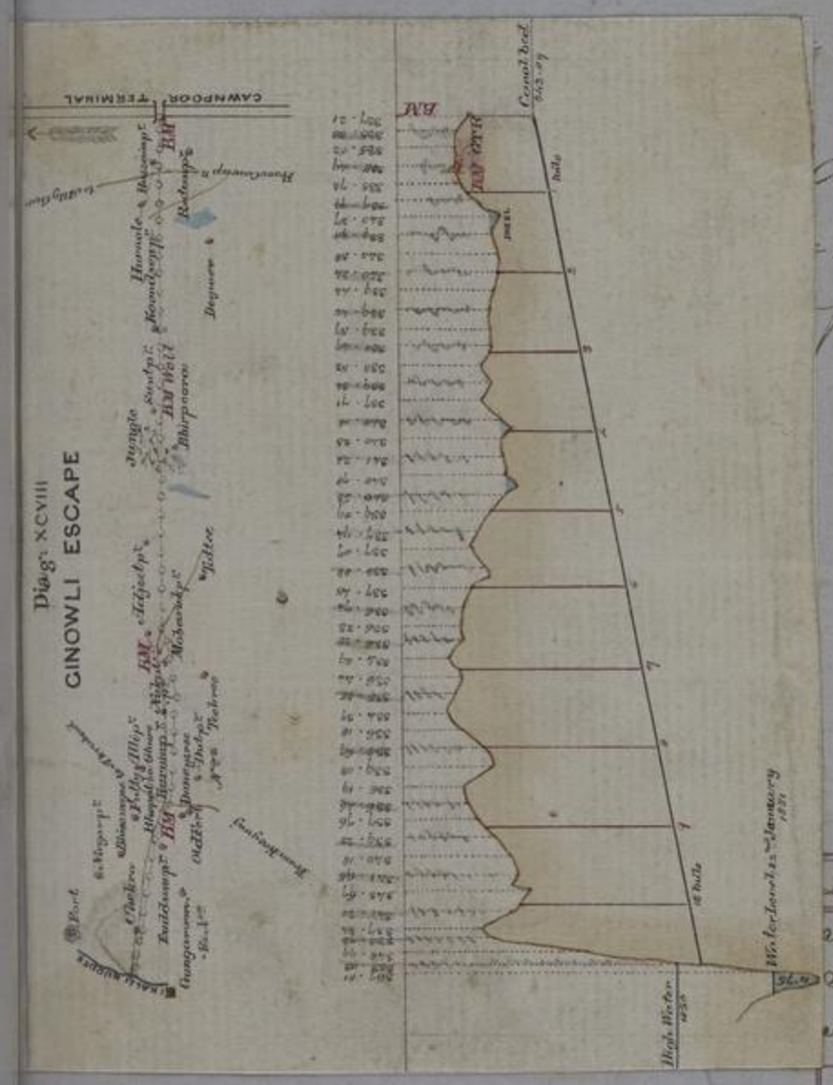
Here as in the cases before described the bed will be regulated from the Escape Head as far as the leading Bridge over which the Rajbuha superpassage is carried; beyond that point, although the building of the necessary works is contemplated, it will not take place until the retrogression of levels caused by excess of slope shews the absolute expediency of carrying them into execution

The disposition of the works, and the particular points regarding slopes will be understood from the following diagram.

(Here Insert Diag: XCVIII



Length of Channel from the Canal to the East Nalli Nuddi		10 Miles 2652 feet
Total Fall from the bed of Canal to bed of East Nalli Nuddi		28·67 feet
Tail Slope of Escape Head	= 1·00	
Slope in 11 Miles @ 1·5 ft per Mile	= 16.50	17·5
Balance Superfluous Slope		11·17

Which will be disposed of in 2 Masonry descents of 5½ feet in depth each, the leading one as in other cases being that appropriated to the Rajbuha Superpassage

A Bridge for the passage of the Grand Trunk Road, crosses the Escape Channel at a distance of 3724 feet from the Head; a waterway of 30 feet clear has been given to this bridge, as the amount of water collected for the country drainage will be considerable. This amount of waterway might, in my opinion, be given to all the

the Bridges on this Escape Channel.

The Channel has been excavated on the same economical plan as that usually adopted its width is only ten feet, just sufficient to give a free and open passage for a current; which immediately after the Canal supply was admitted might be passed down with the sole object of extending its dimensions, and preparing it for the large bodies of water which the rainy season would bring to bear upon it. The soil through which this Channel has been excavated is of a more tenacious character than that met with in the upper districts of the Canal, and it will consequently, I fear, offer more opposition to the effects of a current of running water ~~and lead to greater delay~~ in increasing its dimensions, than may be convenient. Should this be the case, it will be advisable to aid the operations of the Current by further excavations, as the early insurance of this line as an efficient Escape is an object of undoubted importance to the Country in its vicinity.

The proportions of material used in the Cement were

5/6ths Kunkur. Lime
1/6th Bujree.

The quantity of material used and the rates of the work executed were as follows:

	Bricks 3" Mod.	Blocks Kunkur Concrete	Kunkur Lime Mds	Bujree Mds
Masonry	85200	2270	5800	1136

Masonry of all sorts	14	12	7	Rs 100 Cubic feet
Plastering	2	11	3	Rs 100 Sub feet

The Ginnowli Escape was begun and completed under the Superintendence of Lieut Hodgson of the Bengal Engineers, at a Cost of Co Rs 2213.. 5..9

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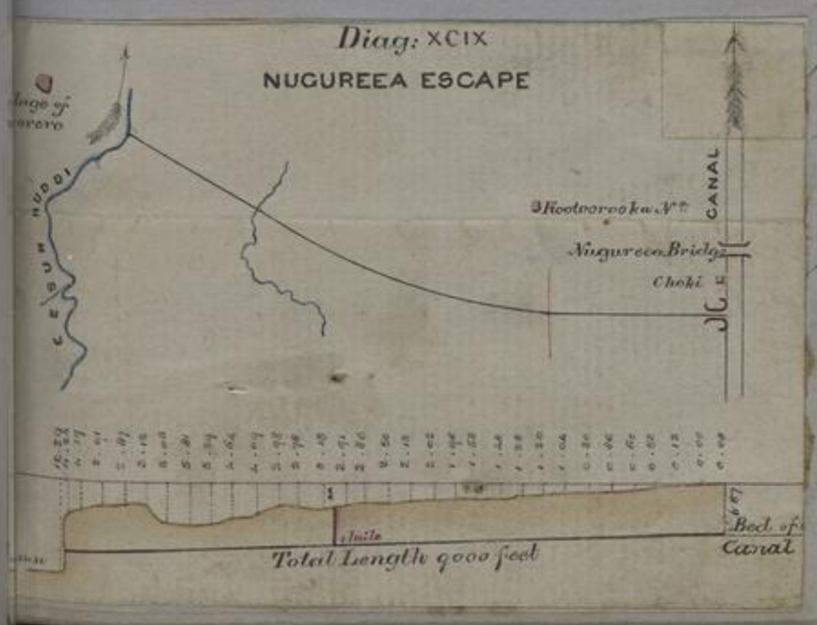
No 2. Nugureea Escape

Immediately above and attached to the Nugureea Bridge which is situated 14 Miles below Ginnowli, a second work for the purpose of regulating supply has been constructed under the above name ~~has been constructed~~. At this point the relative levels of the Canal bed and ~~that~~ of the Rinde River, made it necessary to turn our attention to the Cesun, which forms the left boundary of the tract of country upon which the line of the Canal is carried. The River Cesun has at the point of its course on which the Nugureea Escape is directed, passed through 36 Miles, on the whole of which it has been close to and in parallelism with the Canal. The relative levels of the two Channels, and the disposition of the works connected with Escape, will be understood by the following Diagram, the Head being situated on the left bank of the Canal.—



Length of Channel from the Canal to the Cesun River		9000 feet
Total Fall from bed of Canal to bed of Cesun		5·42 feet
Tail slope at Escape Head	1·00	
Slope at 1·5 ft per mile	2·55	3·55
Balance - Superfluous Slope -		1·87 feet

It is doubtful whether it may be necessary to build permanent works on this line for the protection of the bed slopes, as during floods the high water in the Cesun will stand well back in the Escape Channel, the Surpassage for the left main Rajbaha, however, must as usual cross the Escape, and it will be equally necessary for the convenience of the Agricultural community to build a bridge The same plan, therefore, will be adopted here, as has elsewhere been put in practice; viz^z: the Surpassage Channel will be connected with a bridge, the downstream tail of which will be terminated by a fall sufficient to overcome the excess of slope, and to adapt the Channel to the passage of water during the dry weather, without the inconvenience of over and tem-. I have when describing the Cawnpoor Terminal line pointed out that the additional supply of water which the Nuguree Escape gives to the Cesun, will make an increase of water very to a Bridge built over the River near the Town of Mynpoori ~~very desirable~~ the bridge itself which is on the high Military Road between Mynpoori and Agra has for the last 20 years been in

817

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in a State requiring repair and modification, and the improve-=ment to its approaches, which will necessarily take place under the alterations which I have re-=commended, will add greatly to the facilities of cross commu-=nication.- The site of the bridge in question is 16 miles below the junction of the Nuguneea Escape and it is situated in a valley of considerable width, and of great beauty from the verdure which attaches itself to all this line of River.-

The Nuguneea Escape Head has 5 Sluices of 6 feet in width each, with an excavated Channel equal to 30 feet in width. The design is similar in all respects and in not being connected with the Bridge by masonry work to the Moondakhera & Kanchpore Escape heads, except-ing extent of Waterway to the Moonda Khera and Kafsimpore ~~Escape heads, and, as in their case, is connected with the Bridge by line of steps.~~

The proportions of material used in the Cement are:

2 parts Kunkur Lime
1 part Bujree

~~The total quantity of Material used, and~~ the rates at which the work was executed are:

	Bricks 3 Inch	Block Kunkur Cubic feet	Kunkur Lime Maunds	Bujree Maunds	
Masonry					
Masonry Spulisats	15	12	7		pr 100 Cubfeet
Plastering	2	11	6		pr 100 Supfeet

The building was begun and completed under the Superintendence of Lieut Rodgson, at a Cost of Company's Rupees 3340.. 5.. 11 -

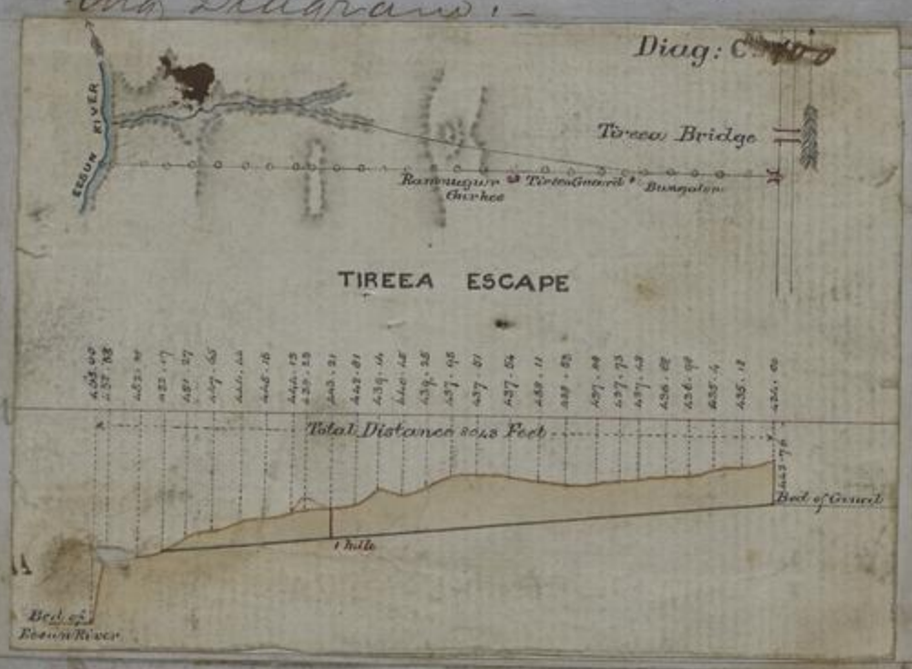
No 3 - The Tirrea Escape -

Here, again from the in-
=sufficiency of the Channel of
the Rinde River to receive addi-
=tional water, the Canal Escape has
been turned to the Cesun - It will
be observed by reference to the
Map, that at a point between
the 82nd and 83rd Mile, and from
the village of Davodpoora which
stands on the most elevated ground
between the Rinde and the Cesun;
lines of drainage flow off towards
both Rivers, the larger one on the
left of the Canal which I have
elsewhere described, as the Dussum-
=poor Nulla, being in the lower
part of its course a Ravine of
great depth and size. This nulla
appeared to be an appropriate
site for Escape water, and it has
been used as such for the drain
=age of the lands lying above it.
It was advisable, however, from
the amount of drainage which
we had passed into the Dussum-
=poor Nulla, to reserve it for that
purpose solely, and with this
view, an Escape for regulating
the Canal supply was fixed at
a point 4 Miles lower down,
where the Cesun is in closer prox-
=imity with the Canal, and
where the Channel of Escape
will be maintained for its own
legitimate purposes

The Tirrea Escape, therefore
is situated at the 87½ Mile, its
extent of water way, and design
~~in Connection with the Western~~
~~side of a Bridge~~, being the same
as that at Muguera.

The

The disposition of slopes will be understood by the following Diagrams:-



Length of Channel from Canal to Eesun River		8043 feet
Total fall from bed of Canal to bed of River		20·24
Trial Slope at Escape Head	1·00	
Slope at 1·5 per mile.	2·28	3·28
Balance - Superfluous Slope		16·96

As before described, this superfluous slope which will be gradually reduced by retrogression of level through the line of Ravine by which the Escape reaches the River will be fitted with masonry works hereafter; three descents each of 6 feet in perpendicular drop, will be ultimately required, of these one to which the Rajbuha passage will be adapted, will be built immediately; the remaining two will stand over until retrogression of levels has sufficiently acted upon the beds.

I may observe that this Escape is the most defective one on the Canal for Terminal line, and as such, its centrical situation is fortunate.

The proportions of ingredients in the Cement are about
1 part Kunkur Lime
1 part Bujree.

The total Quantity of Materials us
and the rates of the Excavation
and work in general are shewn
by the following Table.-

Bricks 3 Inch	Bricks 2½ Inch	Blocks Kunkur Lime mounds	Kunkur Lime mounds	Stones mounds
38608	3625	11970	5503	4291

Masonry of all sorts	15	..	1	pr 100 Cubic feet
Plastering	2	11	..	pr 100 Sup. feet

and the Work was begun and
completed by Lieut Boulger
at a Cost of Rupees
2792 .. 10 .. 7

821

No 4. Kirkwan Escape

This work is situated
at the 135th Mile, or 42 Miles below
that at Tireea - the Channel is
directed to the Pandoo River,
the Head therefore is on the Right
bank of the Canal -

The size of the Escape Head
is the same as that at Ningreea
and Tireea, viz: 5 Openings of
6 feet each, and the building it-
self with the excavated Channel
is on the same design - its situ-
ation, however, from the inter
-vention of a high Mound on
which the 1st Class Chokee is built
is further removed from the
Bridge, and although, had time
been given, I would have con-
-nected the 2 works by a line
of Ghat, such has not been done
and the Escape itself therefore
stands

The

5

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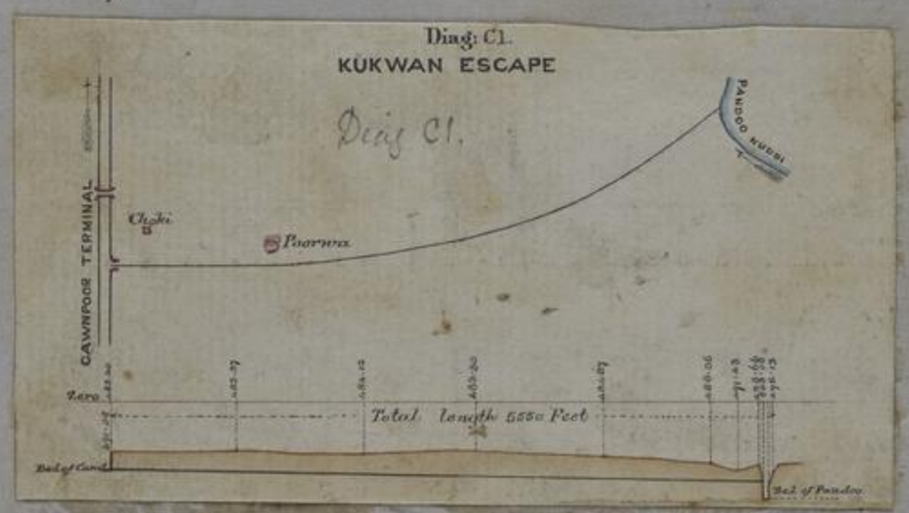
stands as an isolated and uncon-
-nected building.—

The following Diagram will exhibit in detail the disposition of slopes as connected with the Canal and Pandoo on the Kukwan Escape.—

822

Diag C1



Length of Channel from the Canal to Pandoo River		5550 feet
Total fall from bed of Canal to bed of River		11·99 feet
Tail Slope of Escape Head	1·00	
Slope at 1·5 ft per Mile	1·57	2·57 "
Balance Superfluous Slope		9·42 feet

With this considerable difference of bed level between the Canal and the River, we are entirely precluded from using this Escape at periods of maximum high water in the Pandoo when floods to a great extent are running in that River, this high water Mark stands on a level 2·43 feet above the bed of the Canal; the Kukwan Escape, therefore, is literally only of use as a regulator during dry weather, or moderate floods; at these periods its is sealed.— I would nevertheless dispose of the surplus fall above noted, in the usual manner, especially with regard to the Rajbuha Superpassage bridge to which I would give a Tail descent of 6 feet, leaving the remaining Slope to be determined by

by natural retrogression of bed levels: it is possible that there may be no necessity for the construction of further permanent works for the relief of the remaining 3'42 feet, to which the current will in all probability adapt itself.

The Pandwa River in this part of its course has all the objections that the Rinde had, and which in the case of the 3 Escapes above described, led to my preferring the Esuru as a receptacle for our waste water; Having already thrown so much water into the Channel of the Esuru, however, I was not inclined to load it with a further supply, and as the Pandwa was more conveniently situated with regard to the works, at the particular distance at which an Escape had to be built, I preferred taking advantage of its Channel, even under the ~~disadvantages~~ obstacles which have been above explained, to pouring an additional volume during flood season into the Esuru. The Esuru which runs at a distance of 6 miles from the Canal on the line between Rois and Kukuwa is, however admirably adapted for Escape water, its capacity of Channel is great, and the Channel itself runs through an extensive and deeply depressed valley; should, therefore, the Dubowli Escape head which constitutes the leading work of the Terminal buildings and is provided with an Escape equal to 36 feet in width in addition to the Dubowli Regulating

whose

whose head is 10 feet in width, be insufficient to relieve the Canal Channel from flood water which is prevented from Escaping at Kukwan, the remedy is open, in an additional line which may be carried to the Eesun from the Canal either at the Ootha Bridge, or (for the advantages of Supervision at=tendant upon the main post) from that at Kukwan; in the latter case the Channel to the Eesun would be not less than 8 Miles in length, and the Protective works would be proportionately more extensive: I do not think that such a work will be necessary, but if it so, the remedy will be complete

The proportions of Ingredients used in the Cement are

3/5th Kunkun Lime
2/5th Bujree

The total Quantity of material used and the rates at which the Several Kinds of work were executed are shewn in the following Table.—

	Bricks 3 Inch	Block Kunkun cubic feet	Kunkun Lime maunds	Bujree maunds
Masonry	120868	3127	7626	5398

Masonry Mortars	14	5	8	pr 100 Cubic feet
Plastering	3	2	8	pr 100 Sup feet

The work was begun and completed by Lieut Rodgson, at a Cost of Company's Rupees

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On the Cawnpoor Terminal Line, the Power of Regulating the Canal Supply during the dry weather is, I think, by means of the above Escapes in every way efficient: during the rains however, this will be greatly aided by the Rajbaha heads which are in almost all cases appendages to Bridges: the disadvantage under which the Kutcowra Escape labors, will only be felt during extraordinary floods, and as I have before said in such cases, the outlets at Dubowli, which equal in the aggregate, 48 feet in width of waterway, will it is to be hoped do all the duty that is required from them

C. The Escapes on the Etawah Terminal Line

As in the case of the sister branch to Cawnpoor, the works under this section include all the outlets for regulating the Canal supply lying between the Head at Narora and the terminal Escape, which as an integral portion of the works attached to the Lockage into the Jumna River is described under the Head of the Terminal works: the Escape in question is situated at the 170th Mile, and is similar in design, as it is adapted to similar purposes, with that at Dubowli.

The Etawah Terminal line or Branch which runs to the Jumna, is bounded on one side

side by the Rinde, on the other by the Seyngoor River: between these two lines of drainage it continues uninterruptedly for 14.5 Miles of its course, and in this respect it labors under the same disadvantages as the Cumpoor Branch, in so far that the Rinde in the early part of its course, is as inapplicable to provide the means of Escape for surplus water as I have before described it to be. The Seyngoor River which runs on the right border of the strip of land through which the Canal passes, although as deficient in capabilities for the special purpose required in the early part of its progress pon its rise in the neighborhood of Koel, proceeds on a more rapid slope than the Rinde, and, therefore, becomes at an earlier period better adapted for our purposes. At the 50th Mile, the capacity of the Seyngoor and its relative levels with the Canal bed, render it available as a receptacle for waste water; Whereas it will be recollected that the Rinde at the 87th Mile of its course was considered as incapable of being converted to a similar purpose. Below the points above mentioned both the Rinde and the Seyngoor, gradually increase both in width and depth, and would admit of any additional supply that could be possibly turned off from the Canal.—

In determining the positions for Escapes, I have been guided

guided by the rules which were originally laid down, modified to a certain extent by local causes, and in the present case by the peculiar disposition of the lines of irrigation which from narrow to the hundredth Mile, are confined almost entirely to the right bank, and to six leading lines of Rajbaha which cross the Valley of the Seyngoor on their way to the Katrass line of irrigation; these main lines of Rajbaha will in themselves act largely as Escapes for surplus water, and will in all probability without the aid of the Regulating Escape head perform all that especial duty. Within the leading 30 miles of the course of the Etawah Terminal Line, there are no less than three out of the six main Rajbahas above allowed to; I have consequently looking upon these as main lines of Irrigation offering sufficient means for regulating supply placed the Escapes at the following points.-

No 1 Gihror Escape - 57 Mile
2 Mulhosi — do — 103 " "
3 Roora — do — 143 " "

The Escape at the head of the Terminal works and which as I have before said is included in the description of those works, is situated at the 170 ½ Mile

827

No 1. Gihror Escape

The head of this work is situated at the 57 ½ Mile in connection with the Bridge on the High road between Mynpoori and

and Agra: it lies on the Right bank and is joined to the Seyngoor River by an Excavated Channel: the width of the Sluice waterway is equal to 30 feet in 5 Openings of 6 feet in width each: its design is similar in all respects to those which have been before described, and it is attached to the Bridge by Ghats in the usual ogee form. The ~~whole bound of~~ Works at Gihror may be con=sidered as an ornamental ap=proach to the High road on its passage across the Ganges Canal at that particular point.

The disposition of the work, in regard to Slope of bed, and to its Relative position to the Seyn=goor River, will be understood by the following Diagram. —

(Here insert Diag: CII)

Total Length of Channel from Canal to Seyngoor R		4 Miles 1090 feet
Total fall from the bed of the Canal to the bed of the Seyngoor River		10·17
Sail Slope at Escape Head	1·000	
Slope on 4 Ms & 1090 feet @ 1·5 ft p Mile	6·309	7·309
Balance Superfluous Slope		3·861

This disposable Slope might be arranged in a fall at the Rajbuha Superpassage Bridge as has been done in other cases, so as to admit of retrogression of levels in the line of Channel between it and the Seyngoor River, without fear of accident to the Bridge. Here, however, we

guided by the Rules which were originally laid down, modified to a certain extents by local causes, and in the present case by the peculiar disposition of the lines of irrigation which from narrow to the hundredth Mile, are confined almost entirely to the right bank, and to six leading lines of Rajbaha which cross the Valley of the Seyngoor on their way to the Katrass line of irrigation; these main lines of Rajbaha will in themselves act largely as Escapes for surplus waters, and will in all probability without the aid of the Regulating Escape head, perform all that especial duty. Within the leading 30 miles of the course of the Etawah Terminal Line, there are no less than three out of the six main Rajbahas above allumed to; I have consequently (looking upon these as main lines of Irrigation offering sufficient means for regulating supply) placed the Escapes at the following points.-

No 1 Gihror Escape - 57 Mile
2 Mulhosi — do — 103 " "
3 Roora — do — 143 " "

The Escape at the Head of the Terminal works and which as I have before said is included in the description of those works, is situated at the 170 Mile

827

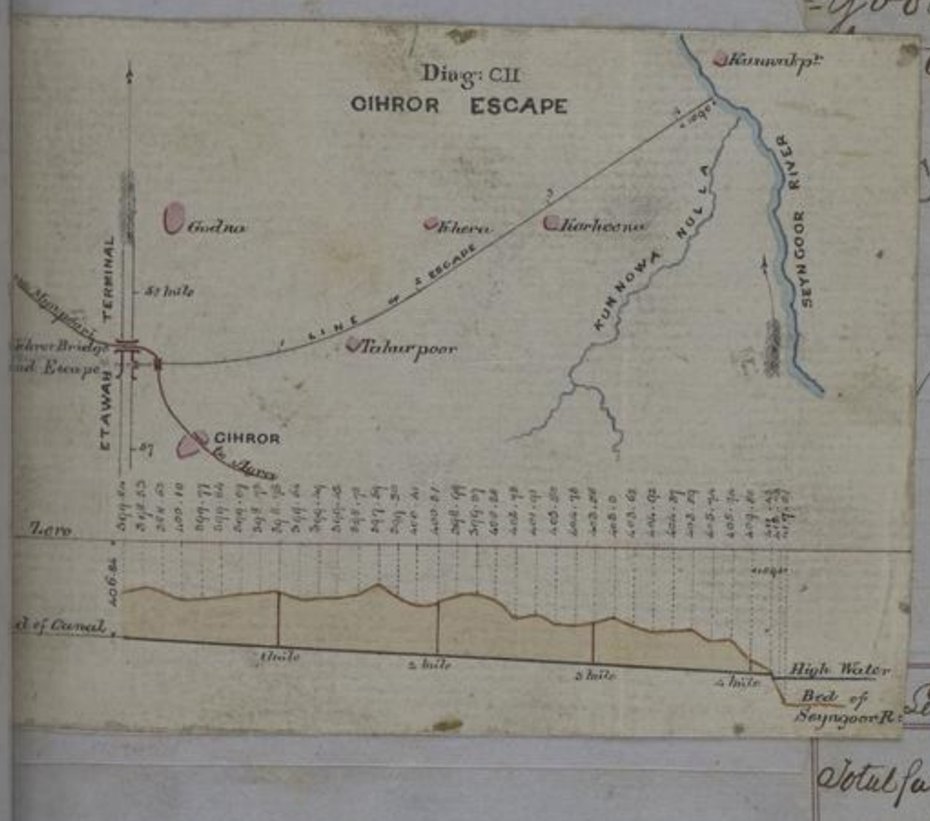
No 1. Gihror Escape

The Head of this work is situated at the 57 Mile in connection with the Bridge on the High road between Mynpoori and

and Agra: it lies on the Right bank and is joined to the Seyngoor River by an Excavated Channel: the width of the Sluice waterway is equal to 30 feet in 5 Openings of 6 feet in width each: its design is similar in all respects to those which have been before described, and it is attached to the Bridge by Ghats in the usual ogee form. The ~~whole head of~~ Works at Gihror may be con=
=sidered as an ornamental ap=
=proach to the High road on its passage across the Ganges Canal at that particular point.

The disposition of the works in regard to Slope of bed, and to its Relative position to the Seyn=
=goor River, will be understood from the following Diagram.—

Diag: CII



(Here insert Diag: CII)

Length of Channel from Canal to Seyngoor R.		4 Miles 1090 feet
Total fall from the bed of the Canal to the bed of the Seyngoor River		10·17
Sail Slope at Escape Head	1·000	
Slope on 4 Mls 1090 feet @ 1·5 f. p. Mile	6·309	7·309
Balance Superfluous Slope		3·861

This disposable slope might be arranged in a fall at the Rajbaha Superpassage Bridge as has been done in other cases, so as to admit of retrogression of levels in the line of Channel between it and the Seyngoor River, without fear of accident to the Bridge. Here, however, we

we have a hard tenacious soil, which probably would obviate the necessity of any protection to the works even in the shape of the fall above proposed, such an arangement would nevertheless place the works in perfect safety - In high floods in the Seynagoor, the water rises to a depth of between 6 and 7 feet; on these occasions there would be back water in the Escape Channel up to the Rajbuhu Superpassage Bridge flooring

The Escape Channel has been excavated on a rectangular width of 25 feet with slopes equal to the depths, the slope of bed being equal to ½ foot per mile: this it will be understood from what has been said before, is a mere economical arangement, the true disposition of permanent slopes being formed (vide Rule 5) on the calculations above figured. -

Kunkun has been largely used in the works at Gibrow, as a building material, and in the difficulty which has attended on brick making, has been of great service in expediting the completion of the work -

The ~~proportions~~ of ingredient used in the cement is: -

Pure Kunkun Lime

The total Quantity of masonry and the rates of the work are:

22676·2 Cubic Feet @ an average of Rs 12..13.10 pr 100 Cubfeet

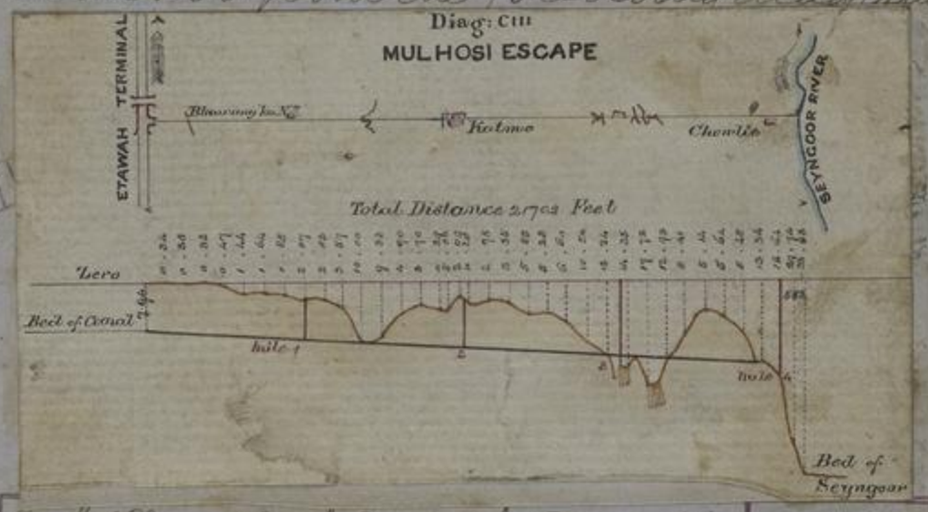
The Gihnor Escape was begun and completed by Lieut Whiting of the Engineers, who as Executive Officer of the Etawah Terminal line, superintended ~~this~~ its construction, and looked after the progress in all its details. The total cost on this work was, exclusive of Regulating Apparatus which will be fixed hereafter Cos Rs 2917.. 3. 2

No 2. Mulhosi Escape

This work which is situated at the 103rd mile, at a point 6 miles below that of Gihnor is in every respect similar to it. In detail of design with reference to the Bridge works at Mulhosi it is identical with that at Gihnor; it provides an escape equal to 30 feet in width in 5 Sluices of 6 feet each, and throws its waste water into the Seyngoor River.

The disposition of the works in connection with the Canal and the Seyngoor River will be understood from the following diagram

Diag: CIII



Dig CIII

Length of Channel from the Canal to the Seyngoor River		4 miles 582 ft
Total Fall from the bed of the Canal to the bed of the Seyngoor River		25·89 ft
Tail Slope at Escape Head	1·00	
Slope at 4 m. 582 ft = 1·5 ft per Mile	6·16	7·16
Balance - Superfluous Slope		18·73

JO

To secure this line of Chan-
=nel on a permanent bed, 3
descents of Masonry with a fall
of 6 feet each will be necesary
- the leading one as usual being
connected with a Rajbaha Super-
=passage, ~~should such be neces-~~
~~=sary~~; this however may be doubt=
=ful, as the Channel of No 6 Main
Aqueduct Rajbaha directly upon
the Patras line of Irrigation takes
its departure from the Mulhosi
Bridge, from the very work in
fact, of which the Mulhosi Escape
head forms a component part.

The proposed line of Escape
Channel enters the Seyngoor close
under the village of Chouni, and
in its passage ~~passes across~~ intersects a
good deal of irregular ground
and cross drainage, which ought
in my opinion to be passed with
-out any attempt at taking
advantage of the facilities which
they apparently offer for reducing
the length of the Excavated Channel.
The first of these lines of cross
drainage occurs at 1½ Mile from
the Canal on the approach of
the Escape Channel to the village
of Kutinwo; it is a wide hollow
with its bed, level ~~with~~ with that
of the Canal, and is connected
with the Seyngoor, to which it
passes in the ~~usual~~ tortuous
course that, as a rule, characterizes all
Nullas of this sort. The second
lies within a distance of a Mile
from the Seyngoor, and between
the road from Pukhroond and
Etawah and that River; at this
point the direct course of the
Escape traverses a whole series
of twists of a line of Nulla, the
bed

beds of which lie considerably below the level of the Canal bed at Mulhosie -

There are very great advan=tages in maintaining an Escape Channel on a straight line, so that there may be as little impedi=ment as possible to the free flow of the Escape water, any interuption to which most materially depreciates the value of the work.. I would therefore, captivating as the Kutmor or that Nulla lying within ½ mile of the Canal, may be both in prox=imity and in Capacity of Channel, pass it entirely; keeping the + Canal Escape in a direct line of bearing upon the Deyngoor River.- At the point of intersection with the hollows to which I refer, I would throw embankments over the Nullas on the left of the Escape Channel only, so that the Nulla water which arrives at that point may be forced to desert its natural course, and take to the artificial line of our Escape.-

The section upon which the Channel will be excavated is the same as that at Gilnor viz.: rectangular on a width of 25 feet with Slopes equal to the depth of digging: the bed Slope equal to 15 foot in a mile

This Work is not yet begun

No 3. The Roora Escape

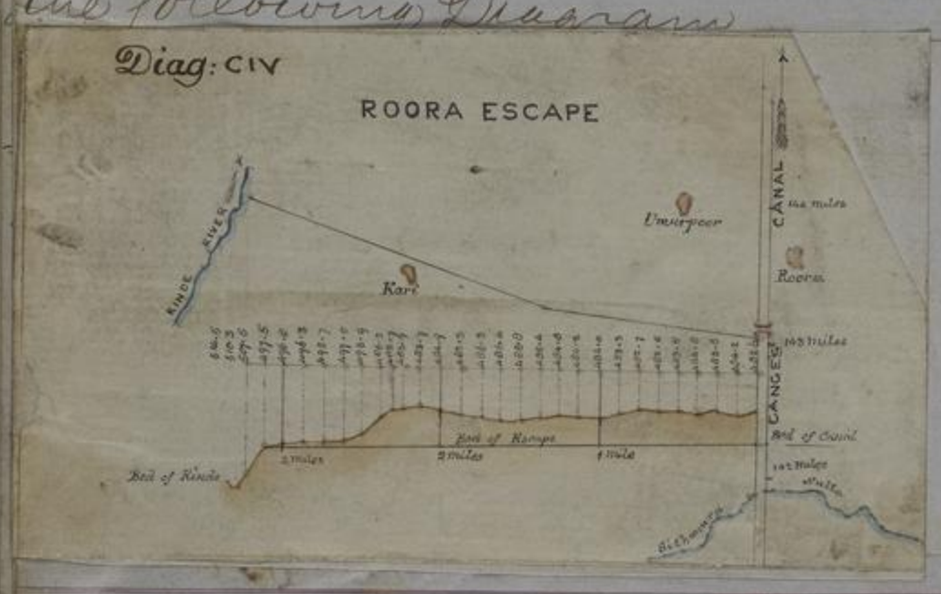
This work is situated at the 14.3rd Mile it throws its water into the Runder River, from which it is separated by a dis=tance of 17200 feet; and the

Channel

Channel is, as in the case of the Ginnowla Escape ~~described~~ on ~~in~~ the Cawnpoor Terminal line, for the double purpose of re=lieving the Country which lies on the left of the Canal from intersected drainage and for giving relief to the Canal Chan=nel ~~in~~ by disposing of its superf=luous water.—

The Roora Escape leaves the Canal above the villages of Roora and Tugaen, at which point the alignement takes an abrupt turn to the right de=serting its parallelism with the Rinde and turning the heads of the Noon River. The Canal where the Escape leaves it has a rectangular width of 18 feet with Slopes equal to depth.—

The head of the Escape is provided with 3 Sluices of 6 feet each, giving a full waterway of 18 feet. The disposition of the Slopes of the Channel between it and the Rinde is shewn in the following Diagram



Length of Channel from the Canal to the Rinde River		3 Miles 1520 feet
Total fale from the bed of the Canal to the bed of the Rinde River		22 ft. 16
Tail Slope of Escape Head	1.00	
Slope on 3 Miles 1520 feet @ 1.5 p mile	4.93	5.93
Balance. Superfluous Slope		1.6 . 23 feet

As it is doubtful whether a Rajbuha Channel will cross this

this line, it may be convenient, with reference to the duties that it is called upon to perform to leave the bed on its excavated slope, without hurrying to com=pletion works for overcoming the superfluous slope; I would, therefore, recommend that all necessary material should be collected for the purpose of build=ing descents of Masonry, to meet the retrogression of level. Should such appear to be work=ing dangerously upon the tail of the Escape; but, I would post=pone their construction until op=portunity offers, or until there is a real necessity for them. — The extensive line of Country which this Channel is intended to drain, and the advantage of extraordinary slope & bed in facilitating the Escape of water, will in all pro=bability make it desirable, to obtain the greatest possible depth to this Channel, in which case, I should be inclined to make the 1st descent immediately at the tail of the Escape head, in the same manner that has been done at the Kheri Kurnoo Escape on the + Eastern Jumna Canal; this + method gives extraordinary facil=ities for relieving the Canal Channel from water, and if the fall is built at a distance from the tail not exceeding 80 or 100 feet, there can be no danger to the Escape head. —

The width of the Channel from the Head to the Runde River is proposed to be 30 feet, with additional slopes equal to the depth

depth; this width will provide capacity for carrying off the Country flood water as well as that from the Canal. For a description of the drainage connected with these works, part II and diagram LIII, should be consulted. —

At the time that I am writing, the works on the Etawah Terminal line, are not sufficiently advanced, to bring them in contact with this part of the Country. - the presence of Kunkur however, which is abundant everywhere, will greatly facilitate the completion of any works that may be required. ~~at this Escape.~~ I may observe in conclusion that the Rooa ~ Escape will be connected with a Bridge, and be built on the standard plan laid down for the guidance of Executive Officers. —

The above building completes the works for regulating the supply of the Etawah Terminal line, their position it will be understood from what has been before said, has been determined in a great measure by that of the Main Rajbuhas connected with the Patras Irrigation, all of which will be useful accessories in the way of Regulating the water. In the case of the Rooa ~ Escape, the position of the work is in some way connected with Country drainage. - The arangements, taken in the whole, will I think be sufficient for the required purposes. —

The only work for regulating supply

supply which lies below the Roora Escape is that at the 170th Mile which as the upstream terminus of the Lock works into the Punna will be described in the Chapter devoted to those works. I may remark however, that the Rajbuhas leading towards the Eastern tracts of the Ghyturnpoor purgunna which commence immediately below the Roora Escape, will ultimately afford their aid to the purposes of Regulation

Wilcox

The subordinate lines of Canal which have been described under the heads of the Futtiguns, Bolundshuhur and Koel Branches as well as the main lines of Rajbuha, are all fitted with works for regulating purposes; to these particular works there is no necessity to make any reference as the execution of the Branches has been postponed, and that of the Rajbuhas was only commenced in May 1853: nor would I offer any opinion as to the advisability of following the design which I have adopted for either the Escape heads or for completing their Channels, the latter is distinctly an economical expedient, and may possibly require modification at any rate the advantages of practical Observation on the works which have been already built on the Main Canal and its two terminal lines, and on the effects of the current depending upon their positions and design, will at a sufficiently early period, place

my

my Successor in a position to remedy any defects and to supply any deficiencies.-

IV. Falls or Descents to overcome Superfluous Slope.-

In projecting the Slopes of a Canal bed, and after determining the amount of declivity of the country upon which the alignement is to be carried, it becomes necessary to dispose of the superfluous fall by artificial means, either by weirs or rapids constructed of piling and Rubble work; or by buildings of a more permanent nature, of Stone or Brick masonry. The longitudinal section, therefore, is laid out in a Series of steps, the length of tread and the height of lift, being determined by the profile of the Country.-

On the Ganges Canal Channel with the exception of the first 2 Miles of its course extending from the Myapoor Regulator to the Kunkhul Bridge where the bed consists of boulders and shingle, and to which a slope of 2 feet per mile has been given; and of the next 3 Miles, extending to the Ranipoor Works, which have a slope of 1½ foot per mile;* the slopes in no case exceed 1·25 feet, and they vary from a maximum of 1·25 to a minimum of 1 foot per mile; at every 3 Miles of its course, and in many cases at shorter intervals, the floorings of bridges act as retainers of the Slope

* as well as of particular Locali- ties on the Ganges Khadir which have Slopes designed for Irrigation purposes

slope, so that were a retrogression of levels equal to the whole amount of the fall between two bridges to take place, the maximum declivity upon the flooring could not exceed 3·75 feet; the action of the current under such extreme circumstances would be still further opposed in all cases where the bridge floorings have been laid in in a light soil, by strong apron of piling and rubble work well clamped together in wooden frames, and ~~further~~ pro=tected by an upper sheeting of sleepers.—

The canal bed it will be understood from the above des=cription consists of a long tudinal series of open lines of earthen channel cunnet on slopes vary=ing from 1·25 to 1 foot per mile, crossed at every 3 miles by masonry bars, and terminated at the ex=tremity of each line by a sudden and abrupt change in the levels.—

In any natural equalization of slope, arising from an ~~artificial~~ absence of regimen; the operation artificial will be limited in the aggregate by the works built for overcoming the change of levels; and in detail by the cross bars or floorings of bridges to which I have before adverted.— The ill effects of retro=gression of levels, therefore, are con=tracted within manageable limits, and it will be well to consider hereafter, when the erection of further Bridges is proposed, that independently of the value of additional cross communica=tion

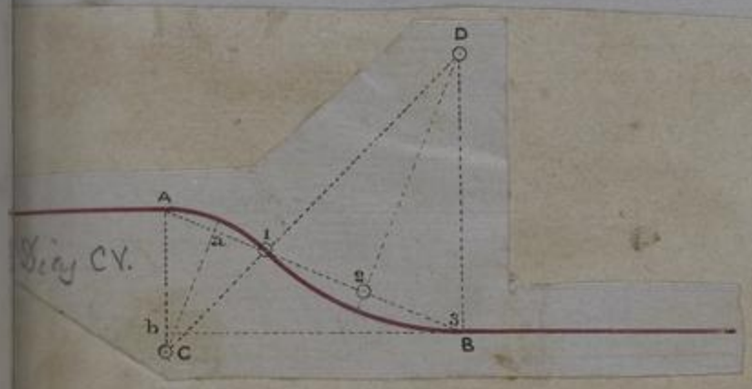
-tion which every work of this sort must inevitably bestow on the Country, its flowings will place a still further limit upon the evils of retrogression —

The design which I had (in the restoration of the Eastern Yumna Canal bed) successfully put into execution, appeared to me to have at least the merit of practical applicability to circumstances attendant on this sudden change from a high to a low level, as well as to the easy ~~passage~~ flow of the Current in passing from one to the other: with the exception, therefore, of details in construction, consequent on the magnitude of the volume of water with which we had to deal on the Ganges Canal, the general design of the Falls may be considered identical: it is in fact a well protected bar or over-fall of Masonry, with its face in the form of an ogee curve for the water to glide over in its passage from the upper to the lower levels. —

Without entering into Mathematical demonstrations of the value of the particular curves which are supposed to be best adapted to the purpose (on which subject much learned dissertation has been expended by De Bossut in his work Sur les ~~digues~~ digues, and by other French and Italian Engineers) I have selected those which from observation of numerous ogees built upon the Canals in these Provinces.

Provinces, and more especially of those which now exist on the Eastern Jumna Canal works, have shewn the most satisfactory practical results of their applicability. The Curve in question is represented by the following Diagram

Diag: CV.



Diag CV.

$bB = \frac{5Ab}{2}$

$A1 = \frac{AB}{3}$

AC } Perpendicular
DB } to Flooring

Bisect A1 and from the point of bisection at 2 draw a perpendicular cutting the line AC at C
Join C1 prolonging the line until it cuts the line DB at D.
From the points C and D as centres draw the Curves of the Ogee.—

Over Curves of the above description when the intermediate obstructions of piers is equal to 4 feet in width, water to a depth of 3¾ feet passes through waterways of 15 and 20 feet in width easily and quietly. I conclude, therefore, that with a depth of 5 feet which is that theoretically due to a maximum supply of water in the Ganges Canal, the waterways of the Falls which are 25 feet with intermediate obstructions of 4 feet, will do their duty equally satisfactorily.—

I must here say a few words on the value of perpendicular descents which have been so strongly advocated, and which nobody can more strongly advocate under certain circumstances than myself. Nature in cases where retrogression of levels occurs in a rocky country, terminates this retrogression by a vertical fall.—

In

In a country where rock does not exist, the prevents this abrupt retrogression, or remedies it rather, by causing the River to run on extended twists, which by lengthening its course, and consequently reducing the Amount of slope upon which it runs, puts a stop to the violent action of the Current and thereby to retrogression. It is true that in the case first mentioned, the perpendicular descent may be qualified by a talus of rocky masses lying at its foot, and in the latter case, varieties of soil may effect the uniformity of Current: but there is the great fact that in Rocky countries where the Surface is divided into extensive flats, lying at different elevations, and forming what are usually termed Steppes, or sudden drops in the position of Table land; Nature pours her water perpendicularly over a precipice, into a vast basin excavated for its reception, and in which the violent action and regurgitation caused by its fall, exhaust themselves. In the absence of rock the natural law is equally apparent; here the water by a gradual process gets rid of its perpendicular fall by a retrogression of levels, and by forming huge ravines, on a course regulated by the tenacity of soil with which it comes in contact, exhibits itself ultimately in an evenly flowing stream, running on a course more or less tortuous depending on the amount of perpendicularity of

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of level that it had to overcome.

As an exemplification of the first case, without going so far as America and the Canadas, the Rewa falls, or those which deliver the water over the great step of the Vindhya Range of Central India may be given ~~as an illustration~~. The Kutti fall has a perpendicular height of upwards of 400 feet. The body of water with the exception of that in the rainy season is small, but during the monsoon the volume is said to be tremendous. I have a vivid recollection of an account given to me of these falls, by my friend the late Colo. Edward Smith of the Bengal Engineers, who paid them a visit during the rains on purpose to test the accuracy of their measurements.—

Of the second case, the Jumna from its junction with the Ganges at Allahabad upwards, the Chumbul from its junction with the Jumna upwards, and the different inland Rivers of the Northern Doab, of which so much has been written in these Chapters are all excellent examples. The Operations of retrogression through high land, with all its detail of tortuosity and lateral drainage, is well exhibited in the regions where the rivers above mentioned join those to which they are tributary. In the neighborhood of Agra even, the Jumna flows through a labyrinth of impracticable ravines equal in breadth to 3 miles,

and

and the Chumbul on the frontier
separating the Gwalior from
the British Territories, runs thro'
a belt of broken and ravine
country, the width of which is
not, I believe, less than six miles;
the smaller rivers to which I have
alluded, although with a volume
of water of an extent compara=
=tively trifling, are in the lower
part of their courses attended
by broken ground of a description
similar to that on the larger
Rivers, and on an extent that
would hardly be anticipated
by those who overlook the causes
and the length of time through
which their effects have been in
operation. —

Although, however, it may
have been convenient for the ar=
=gument to view the action of
Waters as above described under
two separate heads, it must not
be overlooked, that the whole
question of retrogression whether
in Rock, Clay, or Sand, is merely
one of degree. That in both the
cases which I have above quoted
time, and time only, is required
to reduce them to the same cate=
=gory; and that the perpendicu=
=lar fall which Nature gives
to her rocky obstructions is merely
a prelude to its ultimate disin=
=tegration, and to its being worn
away and shattered to pieces
in the same manner that sand
or clay would have been, only
at longer intervals of time. —

Nature in her adaptation
of perpendicular descents to the

volumes

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volumes of water which pass over them, introduces all the necessary elements for this ultimate destruction. the Cataract which by constant attrition wears away the rock on the upper levels; by its action in the abyss below undermines the rock itself; it is limited in its action by no artificial impediments, and it is hampered in its movements by no unnatural restrictions. It is entirely free, and it arranges its own works accordingly

In an artificial fall constructed on the above principles we have the volume of water passing over a perpendicular descent at the foot of which is a deep and spacious basin, capable of receiving the Cataract in its downward descent, and sufficiently capacious to admit of the requisite and violence with which the water is agitated, being expended before it flows off and proceeds onwards.- The building in the case of the Ganges Canal works must have been of brick masonry, that is to say, of small prisms of Burnt Clay (not exceeding One eighth of a Cubic foot in dimensions) cemented together by Mortar, and therefore presenting innumerable seams to the action of the fluid. This building would have been a massive one, although hardly more so than that which has been actually constructed, it would have rested in almost every case in sand, and it would have been protected most securely

from

from bed and side action of the Current - It would in fact have been precisely in the same condition with regard to Material and Soil that the works are at present. -

I must here beg the reader to refer to Plate XXI of the Atlas, shewing the Bahadoorabad Falls which is a fair representation of the works of this description which have been built on the Ganges Canal; - he must look to the general massiveness of the Substructure, to the enormous thickness of the Chamber floorings and work in connection with them, and then bear in mind the fact, that a person standing on these floorings, during the time when a Pile Engine (with a rammer of 1000 lbs weight in a drop of 20 feet) is at work within 10 feet distance of the sill of the Ogee on the upper levels of the Canal bed, feels distinctly the concussion of every blow, and of every descent of the rammer on the Pile head. It appears to be unnecessary to speculate on the way in which the sensation is conveyed, it is sufficient for the purpose of my argument to be satisfied that it takes place, and being so satisfied, to turn the readers attention to the probable consequences of a concussion directly on the building itself arising from the perpendicular descent over a fall of 8 or 9 feet of a body of water equal in Cubic Contents to 6750 Cubic feet

or

A 46

or in weight, to 188·3 Tons per second falling without intermission, and in an unbroken and con-=tinuous volume.—

We Know that in natural Cataracts neither the rock over which the water pours, nor the abyss into which it falls, are in the smallest degree constant, they are perpetually undergoing change and periodically subject to cat-=astrophes. The natural rock is a portion of the "firm, firm earth" rigid and immoveable, excepting by the action of the opposing Cataract— The artificial fall is a collection of small pieces of burnt clay connected into one mass by the intervention of mortar it is in no way connected with the soil in its neighborhood; with it, it is in no ways homo-=geneous; the very circumstances under which it is constructed render the soil in its immediate contact inferior in density to that of the intact and virgin soil which has not been touched by the Excavator; it is in the ex-=treme sense seated in a crater, and in matter that has no sort of sympathy with it.—

I have from the first con-=sidered this question of perpen-=dicular fall, under every imag-=inable point of view that offered itself, and I am fully impressed with the conviction that in dealing with large masses of water as we are proposing to do in the Ganges Canal works, under the circum-=stances of the soil and slope of

of the bed; under the nature of the material with which we are forced to construct our buildings. and under a continuous flow of water equal to that which I have noted above; the perpendic-ular fall would be inapplicable; it would in my opinion be expensive and dangerous and further than this I cannot imagine that floorings made of brick would for any length of time be able to withstand the concussion, and the violent action of the water in the Reservoir.-

Although discussing a principle, I have used the ex-pression 'expense' in the foregoing paragraphs, ~~and~~ this item would in many of our falls have been one attendant in an exorbitant degree on the adoption of the per-pendicular and reservoir plan. The Reservoir to be efficient must have been equal in depth to ~~the~~ the height of the fall, or at least equal to one half of it; its sides and floor-ings must have been built of the most massive proportions, and the work supposing that Brick is used must have been most carefully executed. In cases such as the Puttri Falls where the foundations were actually laid 21½ feet below the surface of Springs, and where I was obliged to sacri-fice the Reservoirs at the foot of the drop at the Lock Chamber, in consequence of the extreme difficulties that we had to contend against; the cost of perpendicular falls with their necessarily attend-ant Reservoirs would have been

enormous

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Hull

Inmouns - the same remark would apply to the falls at Sulawa Bhola, Dasna and Sima at all and each of which the foundations are laid on a level below that of the natural spring surface.

The conclusions that I have arrived at are these: 1st That, in Rivers or Canals where the slope of bed is small, and where back water stands upon the foot of the falls or Annicut (to use a Madras term) the water may be allowed to pass over a perpendicular face the height of which is restricted within moderate limits with perfect impunity, even without the existence of tail reservoirs, the Annicut on the Colleroon is an example of the success of perpendicular falls under the above circumstances; 2nd That in Rivers or Canals on rapid slopes where back water is deficient, perpendicular falls even on a moderate height are inapplicable, and where the height or amount of fall is great and where the volume of water is large, that they are dangerous: I consider, moreover, that this applies to the main streams of the Canals in these Provinces, and more especially to the Ganges Canal. On the minor Streams and Branches (Rajbuhas for instance) where the slopes are moderate and the volume of water small perpendicular falls might perhaps be substituted for the Ogees now in use; I see no special advantage, however, in the change there is certainly none in economy,

as

as the cost of reservoirs would absorb any saving that might be contemplated in reducing the length of the tail flank walls; these walls too are so frequently used as the support of arches for cross communication, that here again nothing would be saved. With regard to maintenance and repair, the effects of falling bodies of water upon the masonry of which our works are constructed might be worthy of consideration.

I am not sure whether noise may lee accepted as a serious and sober reason of objection, but if so, the perpendicular fall would most especially be open to it. In the Khadir there are four falls each with a drop of 9 feet situated within a length of 4½ Miles; to imagine the roar that would be raised by the continuous descent of 188 Tons of water over these perpendicular cataracts, is worthy of the consideration of those who disapprove of the Ogees which I have constructed

I have proceeded to a greater length on the above subject than I had originally intended, but it is one that has given me much thought, and the views that I have adopted have only been decided on after mature deliberation. Fully appreciating as I do the advantages of studying nature in all her operations, I believe that I have, in rejecting the perpendicular descents for the main line and Branches of the Ganges Canal works, shewn in the clearest possible way the advantages that I have derived from this study.

The

The choice appeared to me to lie between an inclined plane and an ogee, both of which have examples on the Eastern Yamuna Canal. My reason for rejecting the inclined plane was that it would have required a greater length of Chamber, with a greater surface exposed to attrition, and in all probability a greater cubic content of Masonry work; the objections were solely of an economical nature, and were quite independent of any peculiar preference.—

The selection having been made of the Ogee shape of Overfall, the curves upon which it was to be described were determined as before noted, and as represented in Diagram CV...—

The falls themselves may be divided into three Series:—

I. Falls with a Drop of Nine feet
II Do Do Eight feet
III.. Do Do Five feet

I. Falls with a Drop of 9 Feet..

Those under this item are confined to the Ganges Khadir, they are four in number and come under the following designation.

No 1. Raniporr, or (Kay's Falls)
2. Bahadoorabad. or (Parker's Falls)
3. Do or (Goodwyn's Falls)
4. Puttri or (Login's do)

As No 1 and No 4 are connected with the Superpassages and form component parts of those works, they have been described in the Chapter devoted to Superpassages.—

No 2 Fall consists of a bridge

Bridge (of 8 Bays of 25 feet in width each) which crosses the Canal on the upper levels, to the tail of this bridge the Ogees are attached deliver-ing the water into four Chambers of 54½ feet each in width, every alternate Bridge pier being pro-longed on its downstream face, so as to divide the Space which is occupied by the lower floorings into 4 Compartments: in advance of these dividing walls which are carried to a distance of 84 feet from the downstream face of the bridge, there is an open Space of masonry flooring, which is protected by an advanced area of Box work, or heavy material filled into boxes or crates, and covered with Sleepers. so as to retain the Material in position. Additional defences are given to these floorings by lines of Sheet piling. The flanks of the Cham-bers below the descent are pro-tected by Revetments, equal in height to ~~that of~~ the dividing walls. These flanks instead of being in prolongation of the align-ment of the Bridge abutments, expand outwardly, gaining on their arival at the tail of the masonry platform, an excess of 20 feet in width. At a distance of 37½ feet from this point, the flanks make a slight curve inwards, terminating (on an imag-inery line drawn in prolongation of the pier next to the abutment) ~~and~~ in massive projecting jetties. Between, and on the flanks of these two jetties, lines of piles, and other protective arrangements are

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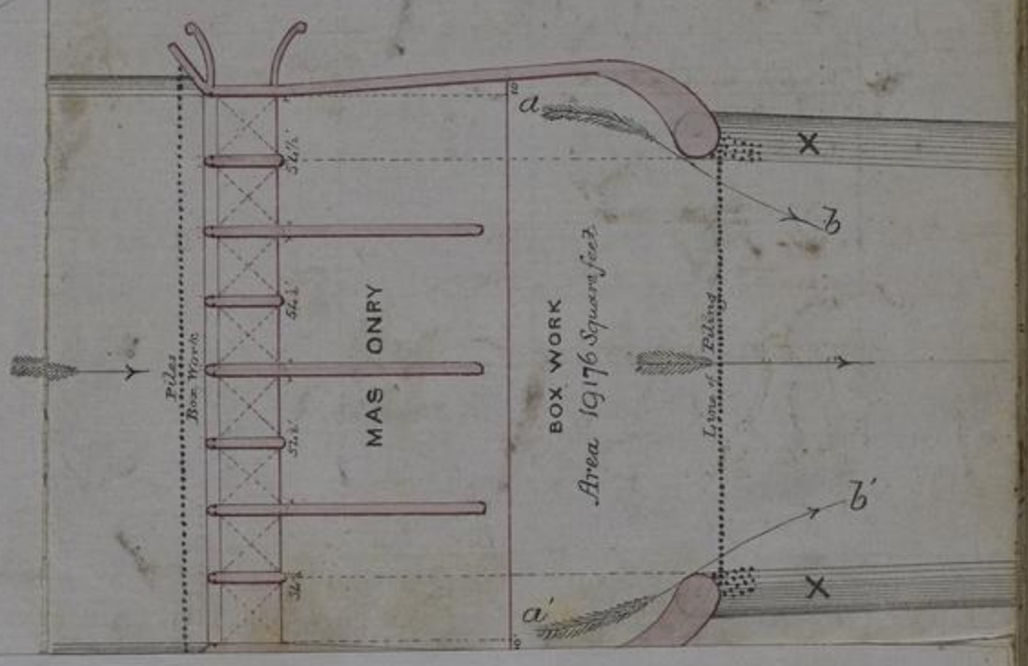
are distributed, so as to secure the safe passage of the water over the floorings, and to admit of the Current escaping from the works with as little tendency to danger as possible. The depth to which the Curtain or upper foundation wall is carried is equal to 20 feet that of the tail with the flank Revetments and Jetties is also 20 feet.

For the plan of this work I must refer to the Atlas, Plate XXI

The following outline in Diagram, however, will shew the general design, and its introduction here will

See other side also.

Diag. CVI.

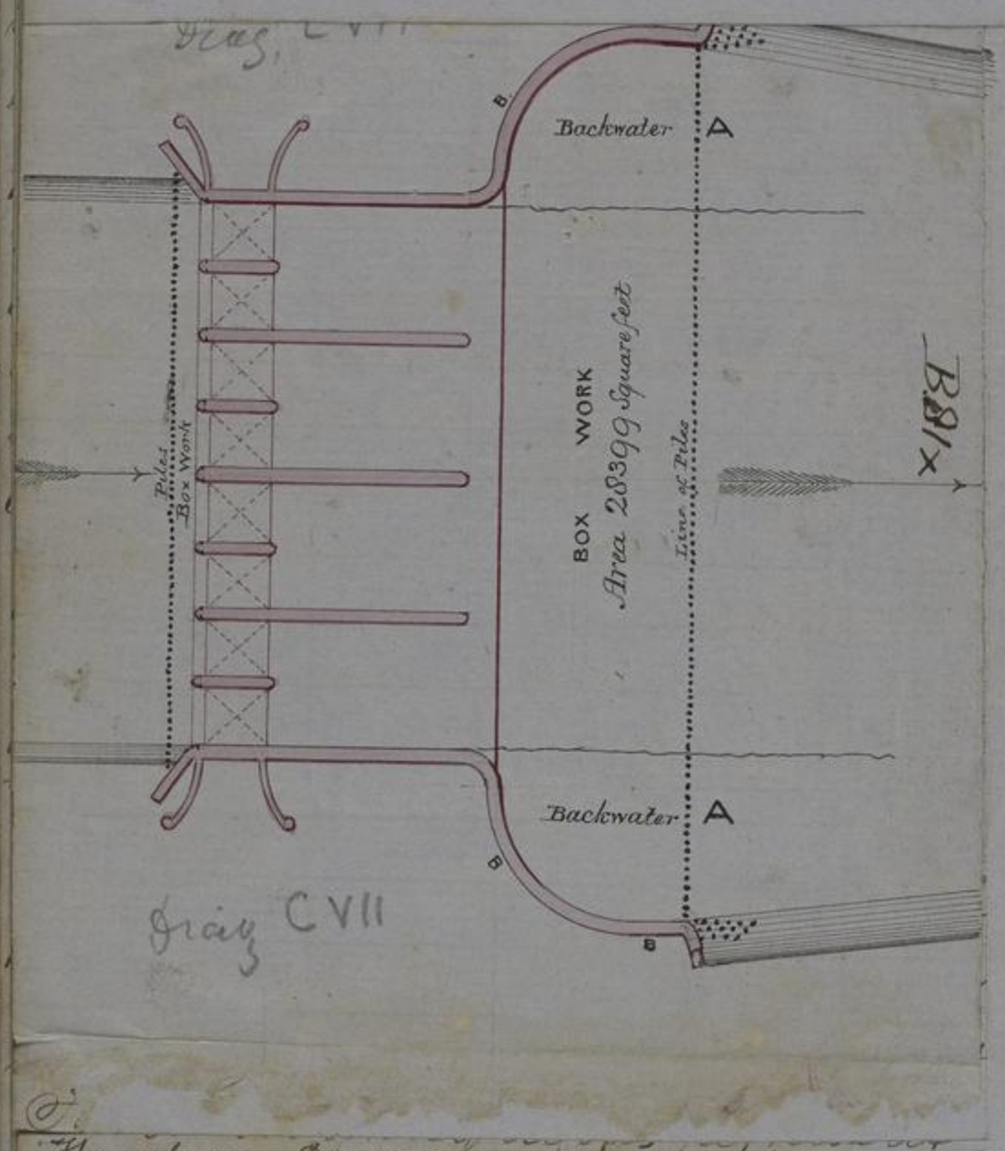


enable me to describe the views by which I have been guided in laying out the Side Revetments, in protecting the flanks, and in endeavouring to secure a safe and easy exit for the Current after its passage over the Masonry descents.

As the above is the plan upon which the whole of the Falls

on

on the Ganges Canal with the exception of those at Bebra (to be hereafter described) have been executed, I shall here give an outline of the works at Bebra so that by putting it in juxta position with that shewn in the above diagram, the explanation that I am about to offer may be easily comprehended.



Diag. CVII

The above Diagrams represent two different plans of flank and tail arangements; that in Diagram CVII, being the original design upon which one work only (viz: that at Bebra) has been executed: that in Diagram CVI, being a modification of the other and that on which the rest of the masonry falls have been completed.

The grand objects in works of this sort are to secure a free and

and uninterrupted passage for the current on its escape from the turmoil and agitation attendant on the passage of the water over the falls: to relieve the current from all provocation, irritation and vexation, on its passage from the Masonry to the Earthen Chan=nel; and finally to use every precaution and expedient not only to direct the current upon the Centre of the Canal Channel, but if possible to maintain it in that position on its forward movement.-

The plans shewn in the above diagrams may be held up as 'active' and 'passive' examples of works designed for the purpose of obtaining the desiderata above mentioned: Diagram CVI. (Active) being so designed that the currents sweep=ing along the feet of the flank walls on the right and left as shewn by the arrows a. b. - a' b', shall, by impinging on the main body of water on its escape from the Masonry building, give their artificial aid to retain the current in a centrical position, and at the same time afford pro=tection to the slopes at x x.-

Diagram CVII (Passive) leaving the desired objects to be attained by back waters as shewn at the point A A.-

Both of these designs have advantages peculiar to themselves: that at Diagram CVII is in use generally on the Eastern Junna Canal, piles being substituted for

Masonry

Masonry Revetments on the curves
B B) that of the CVI. Diagram is
new, and has not yet been tried.
The latter, however, has the merit
of being more compact than the
original design, and of being great
=ly more economical in its con
=struction - It was in fact the
enormous excavations which were
required at the falls at Belva, the
difficulty of disposing of the
Earth, and laying out the
Embankments, and the extensive
area demanding box work at
the tail, that led me to the modi=
=fication as exhibited in Diag: CVI.-

The outline shewn in Diag:
CVI represents the falls which I am
now describing, it will be observed
that they are protected at the head
by a consecutive line of sheet
piling, between which and the
body of the work frame boxes filled
with boulders are placed, the boxes
and boulders being retained in
position by sleepers nailed on to
the pile heads - A similar line
of piles it will be observed con=
=nects the ends of the jetties form
=ing the limit on the down stream
side to the frame box work and
heavy material that occupies
the Space enclosed by the body of
the work and the flank revetments.
This protective area of heavy ma=
=terial has a slope of 1½ feet to
the down stream side; That on
the upper levels and which acts
as an apron to the whole front
of the work, has a similar slope
downwards to the upstream di=
=rection - The flanks on the right
and left both at the upper and

lower

lower levels are strongly protected by piling, the detail of which will be best understood by referring to the Atlas

Alder

Independently of the deep lines of foundation on the upr and downstream sides, built transversely across the Canal, the thickness of the flooring over which the water passes is six feet, it rests upon very fair clayey soil, and with the exception of the upper layers is constructed entirely of boulders and Lime Cement; the Revetment walls, Piers, Arches and superstructure generally are of brick Masonry.

850

The object of dividing the lower flooring into Chambers by division walls, was to afford the means of repair; and for this purpose the Cutwaters on the upper levels have been designed with grooves for the admission of sleepers or vane planks, which are let down from the roadway flooring by windlasses ~~which are~~ adapted to Bitt heads sunk into Masonry blocks - This line of Bitt heads, and windlasses, with nests of sleepers stacked below them, acts as a parapet to the roadway on the upstream face of the Bridge. On the down stream face a Masonry wall gives security to the line of communication.

Steps are attached to the wings of the Bridge so as to give the means of access to the platform on the top of the flank revetments; and flights of steps supported on flying arches enable the Establishment to reach the

the top of the Division walls from the upper roadway. - No2 Falls being situated on the high road between Saharunpoor and Rundwar, has a bridge roadway equal to width to 25 feet. -

The Cement used in this work was composed of

1 Part Stone Lime.
1 " Sookee
1 " Sand

The total quantity of Material used, and the rates of the different species of work, are exhibited in the following table

Bricks	12"×6"×2½"	923500			
Do	12"×6"×2"	728900			
Boulders	———	317225			Maunds
Ghama	———	10919			Cubic feet
Stone Lime	———	75310			"
Sookee	———	71418			"
Masonry Aqueducts	———	12	9	4	per 100 cubic feet
Plaster	———	4	13	11	per 100 Superficial

These works were built under the Superintendence of Captain Goodwyn, and Cost: exclusive of Regulating Apparatus which has still to be fixed Company's Rupees 72788: 8. 11

No 3 Bahadoorabad Falls are constructed at a point in the Canal alignement where there is a deviation of 5½° from the direct line; to meet this obliquity and to give the Current a bearing upon the new direction, a corresponding obliquity has been given to the flank and Chamber walls; the plan of construction may be understood from the figure in Plate XXII, of the Atlas, where the lining out of this work is shewn

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shewn in diagram. The work is in fact built on a curve, the segment of a Circle whose radius is 960 feet. With the exception of the peculiarity in the lining out, the details of building, both in material and dimensions are precisely the same as those at the No 2 Falls. The depth to which the Curtain or foundation wall on the upper level is carried, and that of the tail and its flank Revetments and jetties is equal to 20 feet.

The Cement used in this work was composed of

1 Part Stone Lime
1 " Soorkee
1 " Sand

The total quantity of material used, and the rates at which the work has been executed are exhibited in the following Table.

Bricks 12"x6"x2½	1431220			
Boulders	326088			Maunds.
Khanna	7910			Cubic feet
Stone Lime	75993			do
Soorkee	77670			do
Masonry of Falls	11	7	1	Pr 100 Cubic ft
Plaster	4	3	5	Pr 100 S. feet

These works were also built under the Superintendence of Capt Goodwyn and cost. exclusive of the Regulating apparatus which has still to be fixed Comp Rupees 67613. 10. 3

II. Falls with a Drop of 8 feet

Under this item are included the whole of the Masonry Falls, extending from Ass off nuggur to Dasna or from the 24 to the 105

106th Mile. They may be divided into 2 series depending on their width of waterway, the 1st series being of equal extent to that of the Khadir works; the 2nd being diminished in consequence of the reduction of theoretical volume in the Canal, depending on the abstraction of 1240 Cubic feet per second for the Futtigunj Branch supply; on the expenditure from Rajbuha Heads; and on the causes depending on Escapes. No reduction however takes place until the Channel has passed the leading escape at Khutowli, up to which point it is liable on emergency, to be loaded with water (which may be turned off from the above Branch) in addition to its own supply.—

The Falls, therefore, in this section may be classed under the following heads.—

1st Series with a waterway of 200 feet in width

As of Juggun Falls at the 24th Mile
Muhmoodpoor — do — 31st — do —
Belra ——— do — 42nd — do —
Daoli ——— do — 48 — do —
Chitowra — do — 55 — do —

2nd Series with a waterway of 150 feet in width.—

Talawun Falls at the 68th Mile
Bhola — do — 82nd — do —
Dasna — do — 106th — do —

With exception of additional height to the Bridge Superstructure which is dependent on the elevated Embankments and depth of digging, the design for the works in this first series is

P60

is similar in every respect to that of the Falls in the Khadir which I have before described — The Below Falls which I have pointed out as a solitary instance of deviation from the general plan in the flank and tail arrangements, is in other respects also similar

In accordance with the views which have guided me in drawing up these papers, I shall at the expense of being considered tedious, enter into a brief detail of the different works, noting the peculiarities connected with Soil and Foundations; quality of Material used in their construction, and variations in the details of design, which although trifling in themselves, may hereafter be useful if placed on record — To commence, therefore, in the order of precedence, we have as first on the list

The Ass-of-Nuggur Falls.

This work which is situated at the 21st Mile, is constructed on the Plan figured in Diagram CVI It is built entirely of brick Masonry with Stone lime Cement. Its elevation in design is similar to those which have been constructed in the Khadir with exception to the height of Bridge piers, which have been elevated to bring the levels of the roadway in correspondence with those of the Embankments — Its wing walls are flanked by a flight of steps which give the means of passage from the top of the banks to the berms; on the right and left of the Main Arches, are recesses or niches partly to give relief to the long

long line of wall, and partly to give cover. The Bitt heads, windlasses and sleepers are on an uniform design to those used in the Ba- -hadoorabad Falls.

The pont line of piles and apron and the protection given to the tail and to the flank jetties are on the same plain as before described; the heavy material, which the protection is given being of boulders ~~&~~ round stones brought from the beds of the Rivers in the Khadir.

The foundations are laid in sand of a nature so pure and unmixed that had the Excavations not been made in the high land and at a distance from all drain- -age, one would have supposed that they had been ~~Sand~~ Sank in the bed of a River. I may here draw attention to the quantity of Sand stone concretions that were found irregularly distributed throughout the whole of this excavation con- -nected with the said deposits. In quality and on fracture they were identical with the Siwalik Sandstone. They exhibited themselves in masses of no great size but either in a tabular or a Stalactical form; and in drifts caused by wind one Stratum of the Sand shewed reticulated pipe like lines of the same material, but in appearance resembling straws or roots. The formation is entirely distinct from that of the Kunkur deposits which are intrinsically a recent Limestone formed of Lime and clay; they arise in all probability from ag- -gregations of Sand and Lime, formed by some inexplicable laws of affinity.

As

As these concretions have been found distributed throughout the sand on the whole line of excavations ~~through~~ on ~~out~~ the high Country, it is convenient to refer to them in this place. The proportions of sand and lime appear to exist under great variations; in the Northern Districts the sand predominates, and the mass is ~~intrinsically~~ calcareous a sandstone In the Allegunh, Mynpoori Etawah and Cawnpoor Districts, where there is an excess of Lime over sand the concretions, which I observe in these cases assume a more massive and ~~a~~ botryoidal form, although never exceeding a few inches in Cubic Content, are collected with great avidity, and on being burnt produce it is said an excellent lime.

To revert to the foundations of the Assoffmuggun Falls, which as I have before said are laid in sand. The whole of the walls are constructed in hollow caissons arched over, and the ends of the jetties rest upon Circular Cylinders or wells 20 feet in diameter: sunk to a depth of 20 feet; and used during the construction of the building for the purpose of supplying water to the works: this plan has been universally adopted, and with great advantage on all occasions. The foundation wall in the front, or on the upper level is 20 feet in depth, and 8 feet wide that on the tail is 20 feet in depth and 10 feet wide. The floorings between the foot of the ogee and the tail extremity are six feet in thickness, and the whole work

is

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is constructed on the massive dimensions exhibited in Plate XXXI of the Atlas.

The bricks which were used were made in the vicinity 12" x 6" x 2½" in dimensions, and the proportions of the Cement were as follows:-

1 Part Stone Lime. and from 1 to 2 parts of Sourkee. according to Kind of work

The quantity of material used, and the rates of building are shewn in the following Table.-

Bricks — 12"x6"x 2½		3467766			
— Do — small —		150000			
Boulders		8236			Maunds
Ihama		6250			Cubic feet
Stone Lime		65860			— do. —
Sourkee		85135			do
Masonry including everything		17	3	11	Per 100 feet

The work which was built under the superintendence of Captain Goodwyn, Coll. without the Regulating apparatus which has still to be fixed Cos Rs 91,419 .. 0 .. 6 -

The Muhmoodpoor Falls

The most remarkable feature in the construction of these works, was the extraordinary extent and minute fineness of the sand in which the foundations are laid - The sand in fact was of such a nature, that the whole building was laid in a vast crater or inverted pyramidal frustrum; it being next to impossible without imminent

danger

danger to the work people, to attempt prejudicial excavations.
This sand, as at Assoffnuggur, was accompanied by the concretions which have been before described.
The front foundations, or those which lie transversely across the Canal, and which act as a check upon the subaction of the water, are laid to a depth of 32½ feet, in a narrow wall gradually increasing in width to the higher level; this wall in its progress of construction was carefully imbedded in well rammed sand, an operation which proceeded uniformly with the bricklaying.
The rear and cross walls were built in the caisson fashion as practised at Assoffnuggur.—
The Bridge wings and attendant superstructure were laid over Cylindrical wells sunk to a depth of 40 feet; the general detail of the rest of the work both in dimensions and material are similar to those at Assoffnuggur.
The Niches which are built on the right and left of the Main arches at the falls above described, are here pierced through the building, so that means of access are provided from the upper to the lower side of the bridge; the bridge wings are flanked by steps for the purpose of passage from the Road to the berm Platform, so that the up and down Stream sides of the work are connected by free and open means of communication.—
The front apron and the tail platforms with all their attendant detail of piling and

box

Barnett

box work, have been executed on these works with the greatest care, and if possible with greater attention to stability than elsewhere; the plan is the standard one, as described at Page of Muggur

The bricks which were used in this work were generally speaking newly made from Kilns on the Spot, 12" × 6" × 3" in dimensions; a number of old bricks from the ruins of the Mungloor Fort were also put in requisition; but the floorings are ~~made of~~ coated with selected material viz^t. the best burnt bricks which were especially laid aside for the purpose in the brick manufactories

The piling and frame boxes are as usual of Saulwood, and the heavy material with which the latter are filled, consists entirely of boulders brought from the Khadir

The proportions used in the Cement were as follows:—

1 Part Stone Lime
2 Parts Soorkee

The Quantity of material used, and the rates of building will be found in the following table.—

	Contents of work		Material Expended		
	Cubic Feet Masonry	Sup^e Feet of Plaster	Bricks of all sizes	Stone Lime Cubic Feet	Soorkee Cubic Feet
Masonry	451597	36562	3386,977	75266	150532
Masonry of Foundations		12	10	6	per 100 Cubic Feet
Plastering		4	14	2	per 100 Sup^e Feet
Metalling —		6	4	7	per "

The Muhmood poor Falls were commenced by Lieut^t Fraser of the Bengal Engineers. The Superstructure with all the wood and Stone work forming the outlying protection to the work were executed

executed under the supervision of Mr Frederick Read; and the Cost was; exclusive of Regulating Apparatus which has Title to be fixed Cost Rupees 80496.. 5.. 8½.—

The Belra Falls

These were the first works of the sort that were commenced upon; I found the work lines out, and the tail foundations walls laid in on my first inspection early in 1848.—

It will be understood from what has been said before that the design of the ground plan of the Belia Falls differs from that of all other works of the sort; the design is figured in Diagram CVII. and the whole work is represented in Plate c of the Atlas.—

The front line of foundations is laid to a depth of 25 feet, and that on the tail to a depth of 20 feet, these as well as the different cross lines under the flooring are on the caisson plan as before noted.— The soil although sandy, the work being situated immediately on the extremity of a ridge of Sand (Bhoor) is of tolerable consistency and of a sufficiently tenacious nature to admit of fair excavated lines, without the inconvenience and evils that have been met with at Muhmoodpoor.— The dimensions of the floorings, the Elevation of the Bridge and Revetments, and the detail of the work

work generally are on the Standard model. The whole work is built of Brick Masonry, the bricks 12" x 6" x 3" being burnt in Kilns situated in the neighborhood; here, as at Muhmoodpoor the greatest care has been given to the selection of the hardest class of bricks for the floorings, ogees, and those parts of the structure which are opposed to the constant attrition of water.—

The protection arrangements both on the upper and lower levels are executed on the Standard plan, and the boxes have been filled with Block Kunkur and boulders the procuring of which at this detached work has been a matter of very great difficulty—

The extent of excavation adopted to the plan on which the tail revetments of this work are built, is very great, and the amount of work in the piling and tail platform proportionately so. A comparison between the areas represented in Diagrams CVI & CVII will shew that the first is to the last as 1 is to 1.4809, or that the quantity of work in the tail of the Bellia Falls is half as much again as that in the others: I have noted on the face of the Diagrams the actual areas of the Tail floorings.—

The proportions used in the Cement were as follows:—

2 Parts of Earths Lime
1 " of Sookee

The total quantity of Material used, and the rates at which the

— 268

the work was built are shewn in the following Table. —

	Content of Work		Materials expended		
	Cubic Feet of Masonry	Square feet of Plaster	10 inches of Rammers Piles	Bushls Lime	Bricks
Masonry	396370	36562	2972775	132123	66062

Masonry of all sorts including Plaster	13	4	4	per 100 Cubic feet
Metalling	6	10	27	per 100 Sup feet

The Bela Falls were commenced under Lieut Fraser's superintendence, and were brought to completion by Mr Read, by whom all the protection arangements have been executed — The cost of the work was, exclusive of the Regulating apparatus which has still to be fixed Comp Rs 77523..3..9

The Saoli Falls

These works are similar to those at Muhmoodpoor, but the soil in which they are founded is of a superior description; the front foundation or curtain wall is 32½ feet in depth, and 8 feet broad; the rear or tail wall is 20 feet deep: the design is on the caisson ~~fashion~~ system which is extended throughout the whole work. In elevation and dimensions the design corresponds with the standard plan of which the Falls at Muhmoodpoor are an example.

The piling and protective arangements are similar in every respect to those before described, the heavy material with which the boxes are filled consisting of Kunkur Blocks —

The main mass of this building is formed of new bricks, with a proportion of the small native brick, excavated from ruins in the neighborhood. The Mortar consists of the following ingredients

2 Parts of Earth Lime
1 Part Soorkee

The Quantity of Material used and the rates of the work are as follows:—

	Contents of work		Materials Expended		
	Cubic feet of Masonry	Sup.ficial feet of Plaster	Bricks of various sizes	Cart.s Lime	Soorkee
Masonry	367130	36562	2753475	122377	61188

Masonry of all sorts	12	7	8	pr 100 Cubic feet
Plaster	4	"	4	pr 100 Sup.fee
Metalling	7	1	2	pr 100 Cub.feet

The Daoli Falls were commenced by Lieut.t Fraser, and finished by Mr Read, under whose supervision the whole of the protective arrange=ments have been executed.— These works cost, exclusive of the Regulating apparatus which will be fixed hereafter Co.s Rs 61368.. 11.. 10½ —

The Chitowra Falls.—

The depth of the front Curtain foundation wall of this work is equal to 12 3/4 feet, on a width of 8 feet. The rear or tail wall is 8 3/4 feet deep on a width of 4 feet.— In other respects the de=sign is identical with that at Daoli.—

This work is constructed almost entirely of the native small brick procured from the ruins of the old Town and Serai of

870

of Chitowa.. The floorings, ogee and other parts subject to the attrition of the Current, have a superficial covering 12 inches in depth of the best burnt new bricks selected for the purpose.-

The frame boxes which constitute the protection to the head and tail of this work, are filled with One foot cubes of Rock Masonry no other material being available. The piling and woodwork in general are executed on the Plans and plan. —

The Cement used in these works consists of the following ingredients

2 Parts of Earth Lime
1 Part of Sookee

The Quantity of material used, and the rates of the work are as follows: —

	Contents of work		Materials Expended		
	Cubic feet Masonry	Superficial Feet of Plaster	Bushels of Earth Lime	Earth Lime	Sookee
Masonry	316995	36562	2377472	105664	52832
Masonry Scale Sets	11	12	9	per 100 Cubic Feet	
Plaster	3	3	6	per 100 Sup. Feet	

The Chitowa falls were commenced under Lieut Fraser's, and completed under Mr Reads superintendence; their cost was, exclusive of the Regulating apparatus which will be fixed hereafter Comprising Acres 55132.13.2 -

With the Chitowa Falls, the 1st Series, or that with a width of waterway equal to 200 feet terminates. In advance there is a reduction of 50 feet to the width, which brings us to the

2nd

2nd Series, which ~~in their order of precedence~~ commences with

The Sulawun Falls.

This work is situated at the 68th Mile from the Myaporr Regulator. With a new series in dimensions we have begin a new series of form for foundations, Spring water being met with at moderate depths, and in the tail walls, blocks having been used universally.

The design of these works is with the exception of the reduction to waterway, which leads to a reduction in the number of arches, precisely the same as ~~those~~ at in the former series. Here we have 6 Bays of 25 feet each instead of 8 as in the former case, and 3 Chambers instead of 4; the Elevation and arrangement of parts is in other respects identical with the larger class of Falls. Neither this, nor the protective arrangements, therefore, which are also on the same plan, demand any further description.

The soil at the Sulawun Falls is superficially good, but it reaches the Sandy Strata at moderate depths from the surface. The Spring water is in fine sand, through which the blocks have been sunk. The Curtain or front wall rests upon the Spring level at a depth from the Canal bed of 12½ feet, it is constructed on the plan before described in caissons immediately in front with their heads covering the lower part of this curtain wall, a line of sheet piling has been driven to a depth of 18 feet. The Tail foundations rest upon a

a line of blocks, which are sunk to a depth of 12½ feet. Both front and rear lines of piles and boxes filled with heavy material act as guards to the work from the action of the Current, the details of these protective arangements are similar to those before described. Blocks of kunkar procured from the Quarries in the neighborhood has been used as heavy material for filling the boxes.

The Sulawar Falls are entirely built of new brick 12" x 6" x 3" burnt in the Kilns in the neighbourhood, and those parts which are liable to attrition of Current are built of selected Material.

The Mortar consists of the following ingredients

2 Parts of Earth Lime
1 Part of Surkee

The quantity of Material used with the rates of the work are:

	Contents of Work		Materials Expended		
	Cubic feet of Masonry	Superficies of Plaster	Bricks of various sizes	Cubic Lime	Surkee
Masonry	325368	24114	24402 60	108456	54228

Masonry of all sorts including Plaster	13	12	8	for 100 Cubfeet

The Falls at Sulawar were built under Mr Read's Superintendence and Cost, exclusive of Regulating Apparatus, and a little work to finish &c Co Rs 57885. 0. 9

The Bhola Falls.

This work is identical with that at Sulawar; the front Curtain wall is sunk to a depth of

of 16¼ feet, with the standard dimensions in width. The tail rests upon blocks which have been sunk to a depth of 21½ feet. In design of superstructure, thickness of flooring, protection to the upper and lower levels, and general arrangement of its parts, it is in no way different from the work last described. Blocks of Kunkur have here also been used in the protective arrangements.

The whole of this work is built of newly burnt bricks, and it was during the whole of its construction under the eye of an European supervisor, who lived on the spot. it has, therefore, if European aid is superior to native, been built under great advantages.

The soil was similar to that at the Sidaseer works.

The Cement used consisted of the following ingredients

2 Parts of Earth
1 " of Lime
" of Sookee

The total quantity of materials used, and the rates of the work are exhibited in the following Table.

	Content of work		Materials Expended		
	cubic feet of masonry	Sup. feet of Plaster	Bricks of 1/20	Earth Lime	Sookee
Masonry	331105	24114	21483287	110368	55184

Masonry of all sorts including Plaster	15	11	9	per 100 Cubic feet
Metalling	5	2	8½	— do —

The Bhola Falls were built under the superintendence of Mr Reid and Cost; exclusive of the Regulating Apparatus which has still to be fixed Company's Rupees 65520.. 6.. 8¾.—

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The Dasna Falls

The same remark applies to this as to the last work. The front curtain wall is sunk to a depth of 20 feet on the stand- and dimensions and design. The rear Tail wall is laid in to a depth of 12 feet without the use of blocks, the brickwork being laid upon the Spring level. In other respects, both in elevation and in the arrangements of its parts it is the same as the works at Sukawus and Bhola.

In digging the foundations of the left Jetty or the Terminal extremity of the Revetment on the left down Stream side, an apparently isolated piece of quick sand was met with. Blocks might with advantage have been used at this particular Spot, but the appliances were

~~Diag CVIII~~

not at hand, and it was considered that a platform resting upon the heads of piles driven a depth of 12 feet, and at close intervals, would have been sufficient for the Stable support of the superstructure; a slight Settlement however took place within 6 Months after the work had been completed, shewing itself in a perpendicular crack about 38 feet from the tail end of the jetty. After inspecting the part affected, and from the nature of the piled foundations, considering that it would be next to impossible to remove them, I adopted the following plan of repair, the value of which must be judged of hereafter. As the most

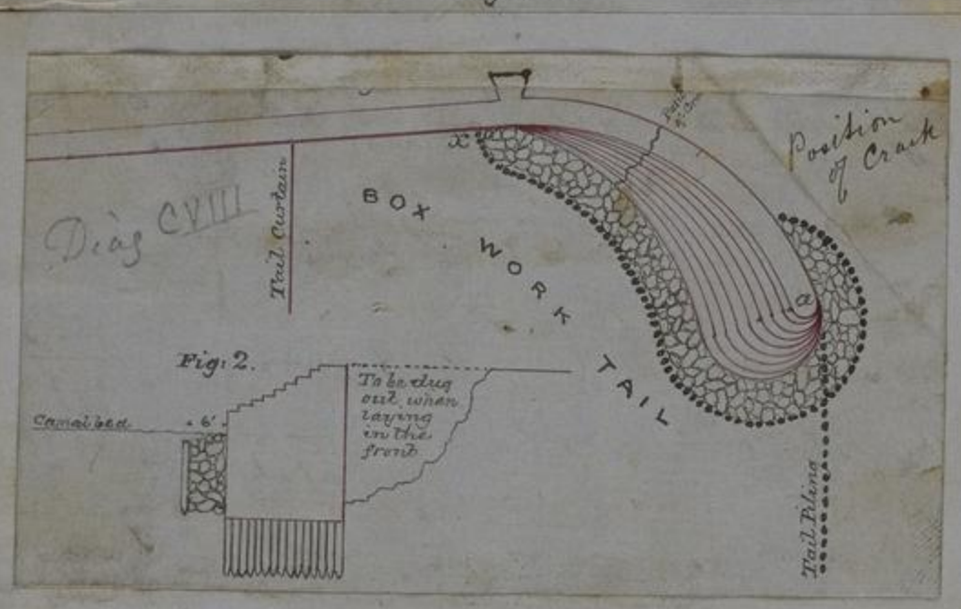
most distinct method of explan-
-ation, I here give an extract
from my Memorandum ad-
-dressed to the Engineer Mr Read,
on his reporting that he doubted
the possibility, with the means
in his possession, of extracting
the piling which had been driven,
even if the Masonry of the Pier
-tures had been pulled down and
removed, for the purpose of re-
-building it.-

(Extract from Memorandum No 119
dated 1st December 1832)

1st To let the Wall Stand as
it is at present.—

2nd To drive a line of 12 feet
Runies or Sheet piling at a
distance of 6* feet from the foot
of the wall as shewn in the
following diagram.-

Diag: CVIII



3rd. When the line of Sheet piling
is completed, the soil between
it and the body of the walls
is to be dug out as deeply as
possible, and the Space so dug
out is to be filled in with
rubble Masonry with lime
Cement (see Fig: 2) This must
be done very carefully, it
must be executed in bits com-
-mencing

*Note. This line of piling was subsequently
there being reason to suppose that the
in driving the Piles acted injuriously
The repair actually made is represented

commencing from the end &
if there is any inattention on
this point and the foundations
of the wall are left bare and
exposed on long lines, the su-
-perstructure of the wall may
fall forwards. To prevent any
possibility of such a catas-
-trophe, Mr Read is advised
to remove the earth from the
rear of the superstructure, so
as to relieve the walls from
thrust as much as possible

The crack at the extreme
end of the levee (the settlement
having taken place apparently
at a' in the above diagram) did
not exceed a $\frac{1}{4}$ of an inch; but
as this particular part of the
work is opposed to all the vio-
-lence of the current, a flaw of
the sort which occurred, could
not have taken place at a worse
point.-

The massive parts of the
foundations and flooring of the
Dasna Falls, are built with blocks
of kunkur, the rest, including
~~including~~ the superstructure has
been entirely constructed of newly
burnt bricks of the standard size
12"×6"×3" as made in the Phrzawa
or native Brick Kiln - The Cement
which has been used is made of
the following ingredients. -

pure Kunkur Lime

The quantity of material used, and
the rates of the work were as follows.

	Contents of Work		Materials Expended		
	Cubic feet Masonry	Sup. feet Plaster	Bricks of Size	Kunkur Lime	—
Masonry	304686	24114	2286645	15244.3	—
Masonry of all sorts including Plaster	13	7	3	per 100 Cub. feet	
Metalling	7	5	7	— do —	

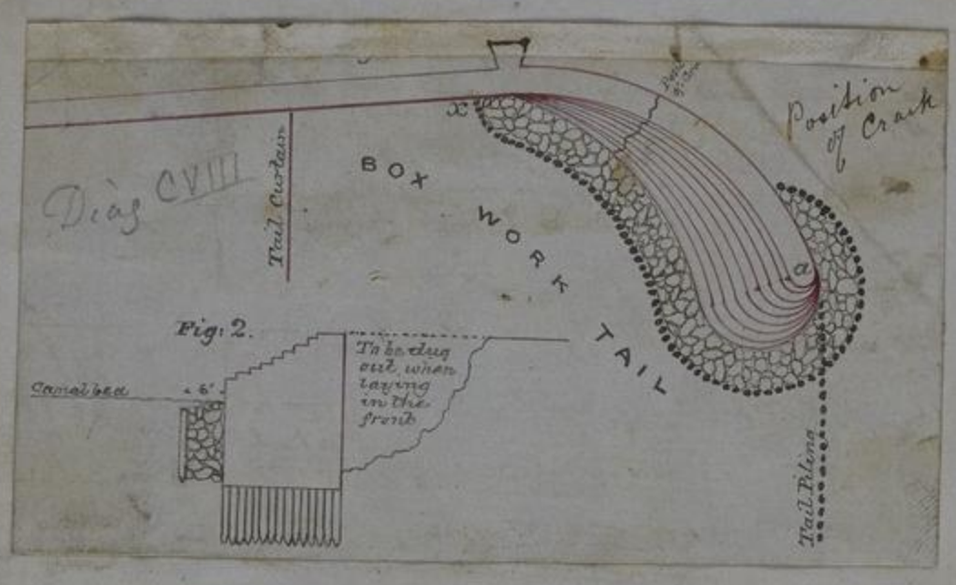
most distinct method of explan-
-ation, I here give an extract
from my memorandum ad-
-dressed to the Engineer Mr Read,
on his reporting that he doubted
the possibility, with the means
in his possession, of extracting
the piling which had been driven,
even if the masonry of the fac-
-tines had been pulled down and
removed, for the purpose of re-
-building it.-

(Extract from Memorandum No 119
dated 7th December 1832)

1st To let the wall stand as
it is at present.—

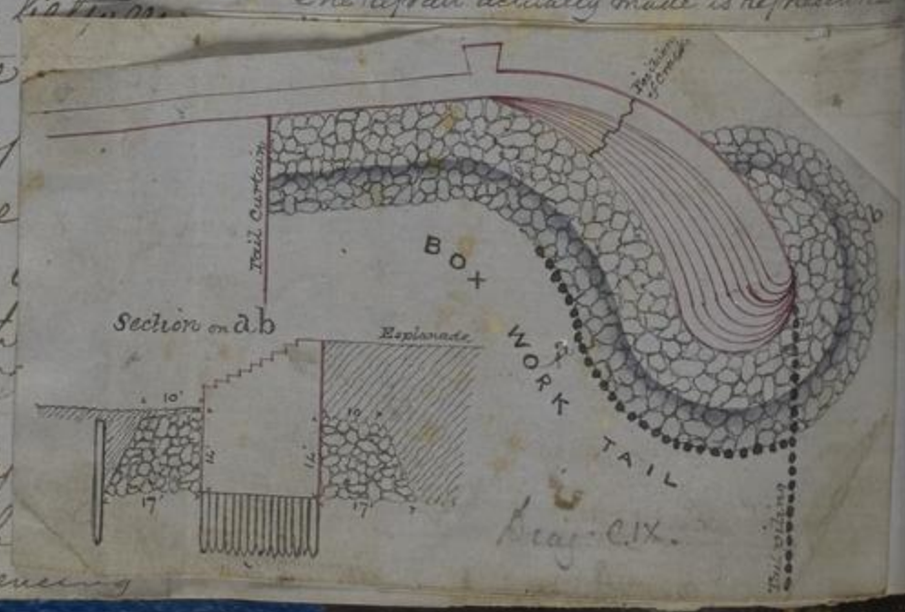
2nd To drive a line of 12 feet
Runnies or sheet piling at a
distance of 6* feet from the foot
of the wall as shewn in the
following diagram.-

Diag: CVIII



3rd. When the line of sheet piling
is completed, the soil between
it and the body of the
is to be dug out as deep
possible, and the space
out is to be filled in
rubble masonry with
Cement (see Fig: 2)
be done very carefully
must be executed in b
-menc

*Note. This line of piling was subsequently
there being reason to suppose that the
in driving the Piles acted injuriously
The repair actually made is represented



commencing from the end &
if there is any inattention on
this point and the foundations
of the wall are left bare and
exposed on long lines, the su-
-perstructure of the wall may
fall forwards. To prevent any
possibility of such a catas-
-trophe, Mr Read is advised
to remove the earth from the
rear of the superstructure, so
as to relieve the walls from
thrust as much as possible

The crack at the extreme
end of the lever (the settlement
having taken place apparently
at a' in the above diagram) did
not exceed a $\frac{1}{16}$ of an inch; but
as this particular part of the
work is opposed to all the vio-
-lence of the current, a flaw of
the sort which occurred, could
not have taken place at a worse
point.-

The massive parts of the
foundations and flooring of the
Dasna Falls, are built with blocks
of kunkur, the rest, including
~~including~~ the superstructure has
been entirely constructed of newly
burnt bricks of the standard size
12"×6"×3" as made in the Ruzawa
or Native Brick Kiln - The Cement
which has been used is made of
the following ingredients. -

pure Kunkur Lime

The quantity of material used, and
the rates of the work were as follows.

	Contents of Work		Materials Expended		
	Cubic feet Masonry	Superficial Plaster	Bricks of Size	Kunkur Lime	—
Masonry	304686	24114	2286645	152443	—

Masonry of all sorts including Plaster	13	7	3	per 100 Cub feet
Metalling	7	5	7	— do —

This work also had the advantage of the constant attendance of an European Officer, who lived on the Spot during the whole of its construction, and who saw the work in its daily progress. — It was begun and completed under the Superintendence of Mr Read and Cost, exclusive of Regulating apparatus which has still to be given Company's Rupees 52639.. 12.. 8. —

The above gives as concise a description as possible of the falls with a drop of eight feet, as included in Section II. and which are confined entirely to the line of the main Canal lying above the head of the Bolundshahur Branch. —

III. Falls with a Drop of 5 feet. —

This Section includes two descents near the Village of Bulra and Simra, which are consequent on the general depression of the surface of the Country, at the heads of the Seyngoor and the Rinde Rivers, they are situated at the 149th and 164th Miles of the course of the main Canal. The Moonda Khera Escape with a waterway of 60 feet in width lies at a point Eight Miles on the upstream side of these descents, and 3 Miles below these is the Kasimpoor Escape, a work on the same dimensions as that at Moonda Khera. —

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818/ to 888

The Bolundshuhun Branch head which abstracts from the main Canal 520 Cubic feet per second. is situated 38 miles above the falls, and the Kool head which is of the same dimensions as that at Bolundshuhun lies between them at a point 3 miles below the first descend.—

From the Dasma Falls which terminates the last series to the head of those at Pulra which commence the present one, the distance is equal to 43 Miles— The Pulra and Sirinco falls are separated by a distance of 15 Miles.

By describing the precise position of these works relatively to the Branch and Escape Heads, their value will be more perfectly appreciated. I have before allumed to the power that we hold in our hands of relieving the Falls entirely from water by the proper adjustment of the Branch Heads and that of the Moorda Khersa Escape:— and of the further power which the Escape at Kasimpoor offers of regulating the supply ~~after it leaves the falls altogether, for the purposes~~ of the Narroon Regulators. We now, therefore, proceed to a description of the Falls themselves.—

The general design is similar to that which has been before described. The width of the waterway has been reduced to 100 feet (to meet the reduced capacity of Channel) divided into 5 bays of 20 feet each, each bay having its corresponding Chamber on the tail flooring. The proportions of the

the work generally, have been adapted to the locality in which it has been built: in other respects the Falls at Pulra and Sirra are a mere counterpart of those which have gone before them. The works which I am now about to describe, therefore, are as follows.—

Falls with a waterway of 100 feet in width.—

Pulra Falls at the 149th Mile
Sirra do " 164th "

The Pulra Falls vide atlas pl: XL

This work has, as will be understood from the preceding paragraph, a waterway of 100 feet in width divided into 5 Bays of 20 ft each, the Roadway is formed by segmental arches of 60° which are thrown over the bays so as to form a passage of 21 feet wide: the piers are prolonged on their down stream side, so as to divide the flooring into Chambers of 20 feet in width, and the upstream face of the Bridge is fitted with shutters, so that in case of emergency a Chamber may be closed. There are the same facilities of access given to the different parts of the works by means of flights of steps, and arched passages on the flanks of the main bays as are given in other buildings of this description, and the flank revetments and jetties are constructed in the form represented in Diagram CVI.

The foundation walls are built solid and not in the caisson fashion before described: the front or curtain wall is sunk to

to a depth of 15 feet. The Flank Re-
-vetments and jetties rest on found
-ations laid at a depth of 13 feet
below the Canal bed.-

The abundance of kunkur,
Quarries of which are numerous
in the Bolundshuhur and Alligurh
Districts, enabled us to dispense
with piles and woodwork, the cost
of which would have been con-
-siderable - the protective arange-
-ments on the upper and lower
levels which in former cases I have
described as consisting of lines of
Piles, and frame box work, are here
exchanged for solid kunkur floor-
-ings, the lines of piles being re-
-presented by consecutive walls,
and the frame box work, by unbro-
-ken sheets of the largest procura
-ble kunkur blocks.-

The falls themselves with
the exception of the Bridge arches
and those parts of the structure
where it was most convenient to
use brick, have been entirely
built of kunkur. The apses and
floorings have a surface 6 inches
in thickness of the best brick
masonry.-

The cement consisted of the
following proportions.-

1 Part of kunkur Lime to
20" of White Stone Lime

In excavating the founda
-tions for the locks which lie
parallel to the Pilra Falls, beds
of kunkur had to be cut through;
clay and a reddish earth locally
called "Kuprcha" however formed
the predominant strata in the
foundations of the Falls; the
soil

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Soil was of the best description that had been met with in founding works of this sort:- and water was sufficiently close to the surface to admit of its free use in the works.-

The quantity of material used, and the rates for building were as follows:-

	Content of Work		Materials Expended			
	Cubic feet of Masonry	Square feet of Plaster	9 Inch Bricks	13 Inch Kunkur nos	Stone Lime mds	Kunkur Lime mds
Masonry	174375	43274	221141	128802	117½	48318

Rates -					
	Arch Masonry	12	.. ..	per 100 Cubic feet	
	Other Do	10	2 8	per do	
	Plastering	2	7 9¾	per 100 Square feet	
	Metalling	2	.. ..	per do	
	Bathends	15	.. .	each	
	Windlasses	30	.. .	do	

The Pulra Falls were begun and completed under the Superintendence of Mr Philip Volk Esqr

Masonry Work	17404	11	1
Protective Works	1630	12	10
Wood Work	240	..	-
Wood and Iron work Nile to be completed	1000	..	-
Total Company's Rupees	20275	7	11

The Simra Falls

These are a counterpart of those at Pulra, with slight deviations in the foundations arising from the contiguity of spring water level to that of the Canal bed.- The Curtain or upper foundation walls of the Simra falls are 15 feet in depth, and consist of a plain line of Solid masonry 6½ feet wide - The tail foundations are laid on blocks sunk to a depth of 15½ feet.-

Kunkur has been used freely here as at the Pulra Falls, it may with the exception of the floorings and Arches be considered the Staple

Material

material of the building.—

The cement is of the follow-ing ingredients

1 Part of Kunkur Lime to
1/20th of White Stone Lime

The quantity of material used, and the rates of building are shewn in the following Table.

	Contents of Work		Materials Expended			
	Cubic Feet of Masonry	Square feet Plaster	3 inch Bricks	Block Kunkur Mds	Stone Lime Mds	Kunkur Lime Mds
Masonry	186063	45059	276304	122790	198	52417

Rates					
	Arch Masonry	12	..	..	per 100 Cubic feet
	Other do	9	14	3	do
	Plastering	2	8	2½	per 100 Square feet
	Metalling	2	..	.	do
	Bittheads	15	.	.	each
	Windlasses	30	..	.	do

The soil in which these works are laid is of an inferior quality to that at the Pulna falls, and the proximity of spring water bringing them in connection with sand; the protective curtains, however, are built entirely of large masses of kunkur laid in with cement, and are sufficient to relieve the work from all danger.

The Sirna Falls were begun and completed under the Superintendence of Mr Volk, and Cost:—

Masonry	19042	2	9
Protective works	1604	12	10
Wood work	240	..	.
Wood & Iron work Nile required	1000	..	..
Total Company's Rupees	21886	15	7

This brings us to a conclusion on the subject of falls; the minor descents which I have described as existing on the Cumpoor and Etawah Terminal Lines being unaccompanied by any works of sufficient magnitude to call for explanation.— It will

will be satisfactory, however, to append a table of the calculated values of the falls above described in connection with their theoretical discharge.-

In drawing up this table I have allowed the obstructions from piers or afflux, to cancel the value of initial velocity: the figures therefore actually exhibit the depths due to water pouring over weirs from a still basin.- My calculations are based on the formula for this species of discharge; because both the afflux and initial velocity were necessarily ~~understood~~ variable quantities depending on the volume of water.- ~~Understood~~ Variable as they were however, their effects were always in my favor by tending to decrease rather than to add to the height or depth of water on the sill or wasteboard of the works.-

The falls on the Eastern Yamuna Canal, which are 50 feet in width, in 1 bay of 20 and 2 of 15 feet each, carry over their sills an average depth of 3 feet of water; the maximum may be considered as 3½ feet although occasionally in the rainy months the register rises as high as 3¾; the actual discharge under the above figures and with the reservations above alluded to, is as follows.-

Width of Waterway	Depth of water on Sills	Discharge in Cubic Feet per Second
50 feet	3·75 feet	1230·375
50 feet	3·5 "	1112·65
50 feet	3·0 "	882·30

Excepting in extreme cases, and there

there only for short periods, the depth of water upon the Sills of the Eastern Ganga Canal falls is 3 feet; it is frequently and generally in the lower divisions under this depth.—

As the action upon the brick=work and floorings of the above works (with the design and con=struction of which I was ~~familiar~~ ~~acquainted~~) was well known, and could after an experience of 20 years be well appreciated, I con=sidered that in the Ganges Canal Falls, we might with perfect security increase the above depth upon the Sill to five feet, or even as far as six; but I adopted the minimum quantity, as that to which we might more satisfac=torily approximate - The disposi=tion of works in the series of water=ways above described is dependent on other causes than those of the discharge of the theoretical volume, to these I have before alluded in describing the position of outlets and contingencies of additional supply to the main Channels from the closing of the Branch Heads - The massiveness of foundations is dependant on the nature of the soil, which in most cases is Sand; it was not thought worth while, however, to alter in their minor details Stand=ard plans and recorded dimen=sions for the purpose of adapting solitary works to their own particu=lar locality

The following Table will shew the amount of theoretical volume of water at the head of each

each of the Falls, and the amount of discharge supposing that the depth of water on the sills or upper platform of the Ogee is equal to 5 feet. The formula used is that for discharges of water from Reservoirs over side weirs or open sluices. —

$$\frac{L D \times \sqrt{D} \times 5{\cdot}1 \times 2}{3} = \text{Discharge in Cubic feet per second}$$

	Miles from Mayaveram Regulator	Width of waterway	Depth of water at the Head of Falls	Proportionate Surface velocity of this depth at the Head of Falls in Cubic feet	Theoretical Discharge in Cubic Feet per second
Ayyoffruggum Falls	24	200	5	6667·5	7582
Muhmoodpoor do	31	200	5	6585·	7582
Belva	42	200	5	6502·5	7582
Daoli	48	200	5	6420·	7582
Chitoura	55	200	5	5097·5	7582
Tulavoor	68	150	5	5015·	5686·5
Bhola	82	150	5	4932·5	5686·5
Dasna	106	150	5	4850·	5686·5
Pulva	149	100	5	3994·	3791·
Sirra	164	100	5	3357·	3791·

The amount of volume as exhibited in the 4th Column is liable to a deduction of about 250 Cubic feet a Second, for water supplied to the Navigable Cut, which leaves the Main Canal above the falls:- this deduction may be considered constant, as the Navigable Channel can only be kept in an efficient state, by forcing a current through it. —

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CHAPTER, III.

Works of Communication.

The Regulating & and the Bridges forming part of the works at Myapoor and Dhunowri; those situated at the Terminal lines at Nanoor, and at the Puttiguhk, Bolundashuhur and Koel Branches, together with those connected with the Falls and the different buildings for crossing the Canal at the Terminal locks on the Ganges and & Jumna Rivers, are not included in this Chapter. I confine myself here to bridges which have been built expressly for the convenience of the public, the description of those above mentioned having been included in that of the works of which they form & component parts.

For the convenience of reference, ~~as well as to adapt my narrative to that which has preceded the present Chapter~~, I shall place the works which are here to be described as in preceding chapters in Sections, devoting the leading one to "Centerings" a ~~position which it naturally occupies in subject which in some respects is an exception. Naturally a leading one connected~~ with Bridge building generally, and in the Ganges Canal works particularly where economy of Time as well as of Money, had a most material influence in the progress of the works. It was one which accordingly demanded the earliest consideration. Under this view, the present Chapter

=ter, is divided ~~itself~~ into the following ~~heads~~ sections:—

I.. Centerings
II.. Bridges between the Head of the Canal and Roorkee
III.. Bridges between Roorkee and the Nanoon Fork
IV.. Bridges on the Terminal Lines between the ~~Nanoon~~ Fork and the Terminal works
A. Cawnpoor Line
B.. Etawah Line
V.. Bridges on the Branches

I. Centerings

These may be separated into Two Classes; the 1st, consisting of Timber, on the method usually adopted in Europe; The 2nd, of Earth, or a Combination of earth with Brick ribs, as common to India. On the Ganges Canal works, the above Classes may be thus described.—

Class I. A. Centerings used at the Myapoor Head works
B.. Centerings used in Bridges of 55 feet Span in the Khadir works
C.. Centerings used on the High Land of the Doab.—
D.. Centerings used at the Soldni Aqueduct, and at the Falls in the Khadir or Northern Division of the works

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Class II. A.. Simple Centerings of Earth
B.. Compound Centerings of Earth, and Ribs composed of a rigid Material.—

Before

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Before proceeding with a description of the above, I may remark, that the rule adopted in all cases, ~~where the arches were contained between the same abutments, and were to be keyed at the same time~~, was to relieve the arch slightly as soon after the keying was effected as possible; to continue this relief gradually and according to the circumstances of the particular case, but invariably to have the centering removed entirely within a Month after the arch was keyed.

Class I

Sheet

A. vide ~~Figure~~ 1, Plate XLII of the Atlas. This design was put into practice throughout the works at the Canal Head at Myapoor. With Centerings of this description, the arches of the Regulating Bridge, of the Bochna Inlet and of the Small bridge that lies on the Nulla of that name above the Inlet were built. The Span is 20 feet, and the ribs (placed 4 feet apart) were supported on temporary pedestals made of Brick and Mud, erected close upon the piers. The ribs rested on a striking apparatus consisting of the usual double wedge or pyramidal shaped bolts which were supported by the above pedestals. The results appear to have been satisfactory, although I have no record of the action upon the arches on the removal of the Centerings. The arches are built in 3 concentric rings 6 inches in depth each, and are consequently

Ten
~~Six~~ in number
1

without

without voussoir: their curve is a segment with a rise equal to 4 feet, or to $\frac{1}{5}^{th}$ of the Span. Newly made bricks 12" × 6" × 2½" were the material used.

B. vide Great Figure 2, Plate LXII of the Atlas. The whole of the 55 feet Span Arches in the Khadir and Northern Division have been built with this Species of centering its great merits consist in its being made with the Kurri or Staple rafter brought from the Sewalik Forests; in the Kurries not being pierced or injured by tenon and Mortice; and, consequently, by their being available after use for other purposes. The design is an excellent, and a most economical one, it is due to Lieut Yule of the Bengal Engineers. —

The Method of fixing the ribs in position, was here (allowing for the excess of width) much the same as in the former case; in addition to the flank pedestals, there were 3 intermediate ones, upon which the striking apparatus similar to that used at the Myaporr works, rested, and the process of striking was performed on the plan above explained. These Arches although exhibiting on the Intrados an elliptical curve are all perfect segments of circles, with the voussoirs of brick courses radiating to one centre, the construction in this respect is shewn in Fig 3 of Sheet 2 Plate LXII they are built with large bricks 12" × 6" × 2½". the thickness of the brick being in some cases 3 inches. In the volume of Tables &c &c: will all returns will be found of the Amount of Subsidence

F.

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of the crown of each of these arches, following the removal of the cen-
-terings. During the construction I am not aware that any settlement was observable, and the Terminal bridges of the Solani Aqueduct which were built with these cen-
-terings (the upStream one by Mr Parker, and the downstream one by Mr Logie) are two of the most satisfactory works of this sort that have been completed

C. Vide, 1st Sheet Figure 3, Plate LXII

These were designed by Lieut Fraser of the Engineers who had charge of the 2nd Division in which the lead-
-ing bridges next to those at Roorkee are included. The Centering was only used on six occasions; the cost of carriage from one spot to another was found to be very great, and the delay attending upon its use was fatal to progress: After the completion of the six Bridges at Munglour, Libunkeri Dimat, To-
-galpoor, Bela and Bhopa, the woodwork was converted to other purposes, and the use of earthen Centerings was adopted. The method of giving the ribs and of striking the Centerings needs no particular description; generally speaking it was similar to that laid down for the guidance of Executive Officers, and practised in the former cases. The Munglour Bridge arches were in all their parts elliptical; their brick courses were laid in vous-
-soirs from the 5 centres by which the intrados of the other bridges of this description were described. This is a Solitary example of this Species of

of Arch, and as it so happened, the disarangement on relieving it from its centering has been greater than elsewhere - The bricks used were 12" x 6" x 3" laid carefully in voussoir, the bricks being cut for the purpose The return of settlement of the crowns of all the Bridges built with the above centering will be found in the Table

D. vide Sheets 7 to 9, Plate XXVII

These Centerings were designed by Captain Goodwyn of the Engineers, they have been used at the Bridges on the heads of No 2 and No 3 Falls in the Khadir, and on the Solani Aqueduct. As a detailed description of these centerings is given in the Chapter devoted to the Aqueduct, vide pages 1280 & 1286, it will be sufficient here to observe that the ribs rested on ~~Brick and mud pedestals~~ Timber trestels, and that the striking was performed under the usual rules with regard to time, these Centerings did their duty very effectually.

In all the above cases, the curved surface upon which the brick work was laid, consisted of squared Kunies (the common rafter of the country) laid transversely across the ribs, in close contact but not fastened, over this dry Sorkhi was thrown, partly to rectify irregularities, and to equalize the curve, and partly to prevent the adhesion of the Kunies to the intrados on the sinking of the centering. —

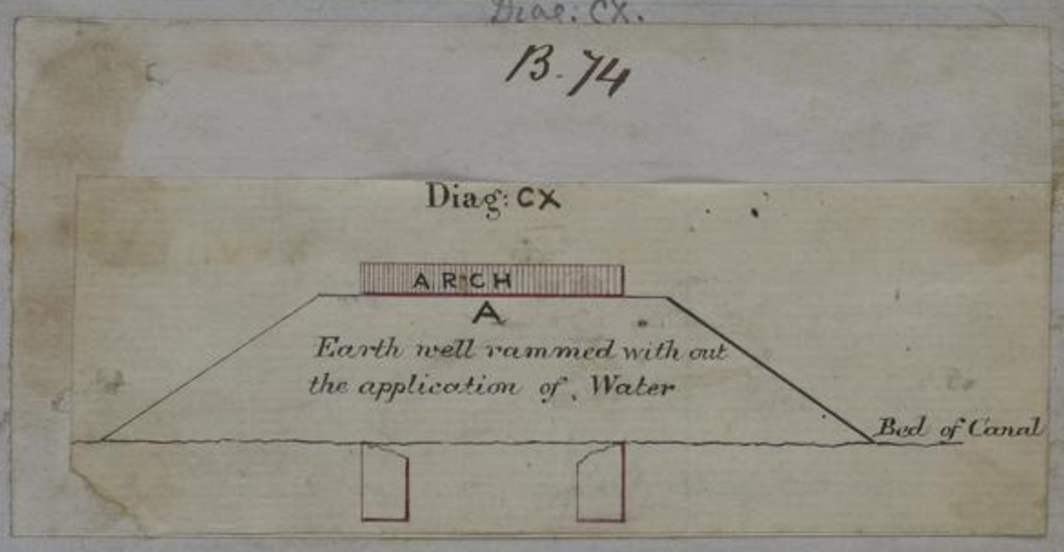
Class II.

A - The Arches of all the Bridges extending from the 47th to

to the 110th Mile, were built on cen-
=terings of Earth only; the design of
which will be best shewn in a Dia-
=gram representing a bridge on
its transverse vertical Section thro
the Crown of the Arch.-

Diag: CX.

B. 74



With the exception of the 8 bridges
at the lower extremity of the line
on which this Species of centering
was used, the Canal Channel had
previously to the construction of
the Arches been entirely cleaned out
and excavated; this was rendered
necessary from the Sandy nature
of the Soil, which did not admit
of rectangular sided excavations
for Piers or abutments; on the con-
=trary, to prevent accidents from the
Subsidence of the Sides, it was a
matter of the utmost expediency
to excavate on long Slopes, and during
the progress of the building of either
the foundations of the Piers and
Abutments, or of the Curtain walls
lying intermediately, to carry on a
gradual process of filling in, the
level of each days work in Masonry
being met by a corresponding level
in the replacement of the Earth-
In extreme cases, therefore, when the
Soil in which the foundation walls
were laid was pure Sand, the whole
of

of the area on which the masonry rested, was one crater or hole, and on the completion of the above walls, the soil in their vicinity was neces-sarily loose and compressible; the floorings of the bays, therefore, were not built previously to the erection of the centerings, nor could the economy which will be noticed frequently, of constructing the cen-terings on the natural terreplein be adopted. The course of proceeding in all the above mentioned cases was as follows: To complete the exca-vation of the canal, to finish the substructure of the bridge in all its parts (with exception to the bay floorings) up to the level of the top of the impost blocks; to fill the bays with earth as shewn in the above diagram; to form the upper part of the surface in the desired curve, and upon it, to build the arch.-

As the results of our leading trials with these centerings had a very material influence on the design for the centerings of the Aqueduct, I must at the expense of some detail, explain the cir-cumstances under which this influence was exerted. The Solani Aqueduct consists of 15 Arches of 50 feet Span each, the width 192 feet being divided in the centre so that the arches might be con-structed separately in widths of 96 feet each. To make Timber centerings for such an extent of Arch work, was not only expensive in itself, but at the period in question was considered to be a work of great time and labor; in the early part of our proceedings, therefore, I had intended

intended to adopt Earthen centerings similar to those in common use by the natives, and the only question that arose was whether to make them of simple earth, or of a mixture of brick wall and earth. As far as economy was concerned the saving of expenditure in using this simple species of centering would have been enormous, and although there were inconveniences in connection with the total stoppage of the waterway, which would have to be remedied by securing the completion of the arches, and the removal of the centerings during three months in the year when no floods could be expected; the plan had great advantages in other respects, and it had my decided support. Before arriving at any conclusions, however, it was advisable to see the results of the Earthen centerings which were at that time in progress of construction below Roorkee, and although the weight of the arches of the 35 feet span bridges was less than that of those of the Aqueduct we should gain some practical information which might be of service. The results were sufficiently unsatisfactory to lead me to discard this species of centering for the Aqueduct Arch, and I could devise no satisfactory method either by brick ribs or by transverse walls of qualifying the evils that were inherent in centerings of this description, without adopting in extenso the native method of building a rigid centering, and allowing it to remain until the masonry of the arch was indurated

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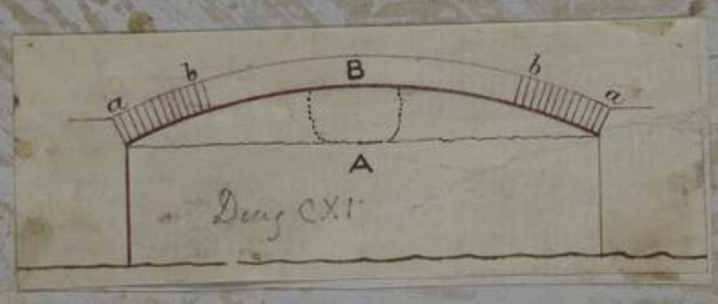
indurated

To explain the objections to the Earth centerings which appeared to me to be fatal to arches intended for the support of large bodies of constantly running water, I will in ~~another~~ diagram shew in Elevation that which has been before exhibited in cross section

Fig CXI.



Diag CXI

A represents the Earth upon which the transverse section is shewn in Diagram CX.. B represents the arch in the construction of which the brick courses are laid from the Skewbacks a a inwards towards b.b. Now in building the arches it was universally observed that ~~when~~ ~~the courses~~ the courses of the brickwork had reached beyond the point ~~at~~ of ~~equilibrium~~ ~~and consequently while the centre of gravity of the material was~~ ~~by the centre of gravity and the~~ ~~the pressure on the~~ ~~gravity acted perpendicularly on the~~ ~~the nature of their~~ ~~in the walls immediately the build-~~ ~~-ing~~ ~~and~~ ~~where gravity acted in con-~~ ~~-tending~~ ~~the~~, there was a tendency to downward action on 2 hinges, one of them at the Skew-back, the other about 4 feet from it; at those points marked a and b in the above Diagram; here there were

of equilibrium and immediately when the weight of the material began to act on the compressible centering;

were distinct separations in the brick work increasing as the arch advanced towards its centre, the maximum width of opening as observed not exceeding 1 inch on the extrados, at the period when the final measure of keying took place. During the operation of keying, and immediately afterwards on the earth being removed from the intrados of the Crown, the separations above described closed, but although this closing was to all intents and purposes as perfectly effected as it could well be, the line of separation was distinctly traceable along the whole width of the arch on its extrados; and I considered it advisable in every case to establish for a week or ten days over the line of separation a trough of lime water so that the continued percolation might restore the Masonry to its original integrity

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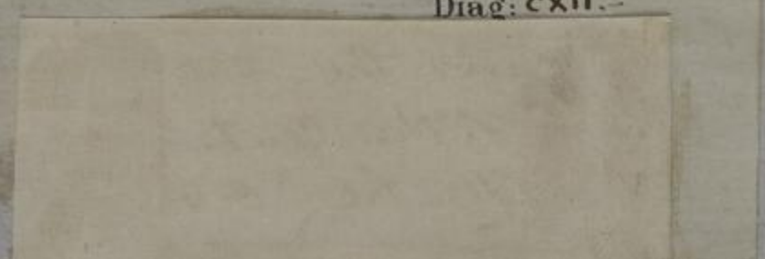
Diag: CXII.-



However unimportant such a defect might be in Arches for roadway purposes, I concluded that for an Aqueduct carrying a depth of 10 feet of water, it was quite inadmissible; the Aqueduct arches moreover being considerably heavier, would in all probability be attended by separations of a much

much more serious character; & Earthen centerings for the Aqueduct therefore, were at once abandoned, and at this period the design which has been now carried out, and which was most Opportune-ly suggested by Capt.n Goodwyn the Executive Engineer of the works, relieved my mind from any further anxiety on the subject

The Earthen centerings therefore which were built in the 2.nd Division, were the experimental guides to those of the Solani Aque-duct, whilst in their own Espe-cial duties, they acted satisfactorily and were the cause of great sa-ving both in time & expenditure. The value of Settlement of the Crowns of Arches in all the bridges where this Species of centering has been used, will be seen in the Table and from this a comparative Es-timate may be made of the amount of depression in other cases of the Arch under the different Varieties of Centerings which have been used.

I may observe in con-clusion that immediately the Arch is Keyed, parties are placed so as to remove the earth from that part of the Centering lying directly under the Crown, & within the dots marked in the dia-gram, after the removal of this, it will be understood that that part of the centering lying to the right and left is easily got rid of. in fact, from its Elevated Po-sition, the laborers are able to dispose of the earth, and throw it on the lower levels with little waste of time, and with little

Expenditure

907

expenditure of exertion —

The arches in this series were, with the exception of the bridges of the 3rd Class (as described in the following section) which were made with small native bricks, built entirely of new bricks 12" x 6" x 3" with excellent Mortar, used as sparingly as possible, and semifluid, whilst the bricks themselves had been previously, to their being laid in the work, well soaked in water

B. In the Centering above noted, we have a material homogeneous and as far as earth is so, equally compressible on all the surface on which the arch is laid: in that which we are now about to describe we have a mixture of rigid and compressible material, and in this respect theoretically inferior to the other; it has the advantage, however of preserving the form of the arch in the true curve on which the segment is designed, and with proper management of maintaining a sufficient equilibrium in its parts, to prevent irregularity of depression. This species of centering has been used on the whole of the works from the 110th Mile downwards, and has been practised with more or less success in all the bridges where the Span of the arches has varied from 45 to 20 feet in width. —

The following diagrams will shew the method of construction adopted in this particular case, where the natural soil and the terreplein ~~is~~ are converted into a support for the centering

the

the artificial portion of which in many cases consists of the curve upon which the arch is designed. —

Diag: CXIII

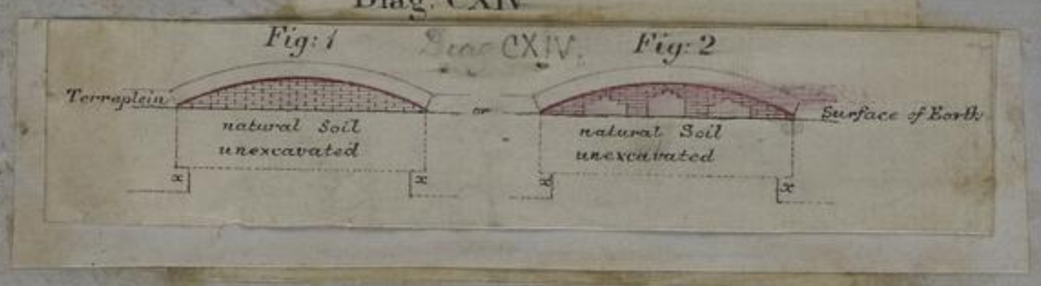
Transverse Section on Crown of Arch

B.77

A representing the Earthen Centre supported on each side by the Walls BB, built of brick with mud cement, constructed in such a way that it can easily be separated —

Elevations shewing the above on different methods of construction each of which is intended to facilitate the removal of the brick ribs from under the crown of the arch as rapidly as possible after the arch has been keyed. —

Diag: CXIV



In both these cases it will be observed that the piers have been built with the natural soil between them unexcavated. the inner part of their foundations at x x being prepared for after construction and bond of the flooring and curtain walls when the centerings and the earth which ~~have~~ been left for their support ~~have~~ been removed. The artificial por-

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f. P. P. 209
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portions of these centerings, therefore, are segments of circles corresponding in shape with those of the arch which is to be built upon them. It has been considered sufficient to give two examples of this species of centering, the brickwork however has been built in a variety of ways all intended as before said to facilitate its removal; the omission of every alternate brick in the deepest part of the segment was found to be well adapted to the object in view; but in all cases, the course that was followed in the plain earth centerings, of getting rid of the whole that portion of the centering lying directly under the Crown immediately after the arch was keyed, and afterwards clearing as quickly as possible from the centre to the sides was strictly attended to. -

It will be observed in Diagram CXIII that the earthen portion of the centering is slightly raised technically cambered, a device that was found to be of great advantage in cases where the width of Arch exceeded 21 feet - in such cases, there was an inclination in the brick work to settle unequally, from the compressibility of the Earth; an evil that appeared to increase directly as the distance from the lateral Ribs. In very wide bridges therefore, an intermediate brick segment might perhaps with advantage be used, so as to secure an equality in the settlement, during the period when the arch was building. It is evident that with the com-

-bin-

-bination of compressible and
rigid material which this species
of centering involves, the immediate
relief of the arch is indispensable;
this, however, is so easily managed
that with proper care no delay
ought to take place, and there
can be no doubt that the curve
is ~~accurately preserved~~ better maintained
in cases where centerings of this
sort have been used, ~~than in~~ than in
arches constructed on plain
earth unaided by brick ribs which
have in a greater ~~degree~~ degree
settled down before they were
keyed. —

The process that succeeds
the removal of the centerings
is to excavate the natural soil
~~from~~ on which they are built, and
so to clear out the Canal Channel.
The curtains and floorings of the
bays are then built with as
little delay as possible. By adopt
-ing this cheap plan of centering
the whole of the bridges therefore
~~are~~ deprived of one of the elements
which constitute the Standard
as described in the leading rule
of construction; that is to say,
the arch is allowed to exert its
thrust upon the abutments
before the lower fulcrum is
fixed. —

With the exception of the
few bridges in which Block Kun-
-kur is used, the arches are built
of brick of the size before described,
with the usual care given in the
free use of water. In every case
however, as far as my observation
has gone, excepting in that of the

Skew

Skew bridges (of which I have no accurate record 25 feet Span) the settlement of the crown of the arch after the centering are re=moved, has led to a very slight separation of voussoir at a point from 6 to 12 courses of brick from the Skew back, this separa=tion is to be detected along the whole line of the extrados; while on the face of the arch underneath, or on the intrados where the hinge of this movement takes place, no trace whatever of separation is to be observed. In all cases, where the superstructure was (and exhibited at an earlier period buried forward) subsequent settlement is shewn by its action on the parapets.—

—— The arches of the Ramipoor and Puttri Surpur passages were built upon centerings on a simi=lar plan to that which is here described; the extraordinary width of the arches, in the former case 210 and in the latter 310 feet, called for peculiar care in making the earth as incompressible as possible. brick ribs were limited to the up and down stream ends of the works: and the results have been very satisfactory: the effect upon the haunches after the removal of the centerings, however, was similar to that which has elsewhere been re=marked upon.—

In concluding this section I may draw attention to a plan of centerings which was adopted by Lieut. Fraser of the Engineers when building the Arches (25 feet Span) of the Paoli

Laoli and Chitowra Falls. The positin of the bays at these works, as will be observed by refering to the plan, is most exceedingly awkward for the establishment of Earthen centerings, unless they are increased in extent beyond the usual limit. The locality also is especially inconvenient for the subsequent removal of the earth, and the cost attending upon the whole of the operatin is very great. During the con-struction of works of this sort, Lime burning, (in which copla or cakes of cowdung is the fuel used) was in progres; wood of all the smaller descriptins, such as Kunies, Tors and bullas was also at hand. Lieut Fraser without cutting up any of the wood specifically for the purpose, used it in conjunctin with brick and mud supports, for a superstructure of Copla, laid closely together, and formed on its upper surface in the shape of the required curve; upon this as a centering perfect success attended the erectin of the Arches, which were completed very satisfactorily. Here the cost of the centering was merely the labor of building and pulling down, and both the wood and copla were uninjured and avail-able for their proper purposes. I consider this to have been one of the best of many applicatins of simple means to useful purposes that have been exhibited on these works.

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[illegible] .. Although in none of the centerings that were used, even in cases where the haunches were loaded previously to their removal; did we escape from settlement; it was more prominently shewn in Arches that were built with the plain earth centerings as described under the head of Class II A. In these cases the separation assumed the character of an absolute fissure on the Extrados, until the Keying of the Arch, partially obliterated it; [illegible]

[illegible]

Of the Timber centerings described in this Section I should give a preference to Captain Goodwyn's Class I D on account of its aptitude and convenience in use; to Captain Yule's

Jules, Class I B. for its economy of Timber work - The former being of Timbers cut up for the especial purpose are expensive in manu-=facture; in use they are economi-=cal as the pieces are placed in position separately - The latter as I have before explained are made of the uncut Kunis, or Staple Rafter of the country, which is purchased at a small cost, and is available for its original pur-=poses after the centerings are no longer required. they are not so convenient as Capt. Goodwyn's, from their having to be placed in posi-=tion in masses.

Of the Centerings placed under Class II. B, is undoubtedly the best, in defiance of its being composed of a mixture of rigid and com-=pressible matter; but in using it, the Centering must be removed with as little loss of time as possible, so as to prevent its wound of homo-=geneousness from acting preju-=dicially to the uniform settlement of the arch -

Before commencing on the subject of the 2nd Section of this Chapter, it will be convenient to make a few introductory remarks on the general plan of construction in the building of the Bridges. -

The works of this description as designed for the Ganges Canal, are built entirely of Masonry In the Khadir, or in the tract above Roorkee, Bricks and boulders (or Stones selected from the beds of the Rivers connected with the moun-=tains) the former predominating, have been universally used, with a cement made of the best species of

916

of Lime, obtained from the calcination of crystallized Lime Stone collected in the beds of the rivers in the Deyra Doon and in those of the Ganges and its branches.- In the Bridges below Roorkee and as far down as the 95th Mile, brick is the Staple commodity; below this point, both brick and block Kunkur have entered largely into the con=-struction of all the works, in many of which brick has only been used in the Arches. The Mortar from Roorkee downwards has been made of a great variety of Marls and Kunkurs; near Roorkee and with=in a moderate distance from the Khadir, the use of Stone Lime to which I have referred was extended as far as economy would permit. Marles some of them of a very superior quality, especially that from Dussoor, then took the place of Stone lime, after which and throughout the whole of the Dis=-tricts of Bolundshuhur, Allegurh, Mynpoori, Cawnpoor, Etawah &c., Lime made either from Kunkur gravel, or from that Spe=-cies of rock in some form or other was the staple ingredient for the Cement. —

The Bricks which have been made in our own Manufactories for the purpose of Bridge building are of the following dimensions

12" × 6" × 3"

12" × 6" × 2½"

the best ~~that have been made~~ are those from the Kilns in the neighborhood of Sirdhanna, they are generally good however throughout the upper Districts as far

far down as the Narora Regulators: below that point the soil becomes affected by (reh) an Alkali that appears to deteriorate the earth ~~as regards~~ for brick making. This reh is not universal, but its prevalence leads to the necessity of great discrimination in the selection of ground for brick manufacture: it has led to much disappointment and much pecuniary loss. As a rule, I consider that the bricks used in the works below Narora are inferior to those of the upper Districts, and in the Cawnpoor Terminal line, that both the bricks and Cement which have been used in the Cawnpoor District are ~~inferior to those elsewhere~~. In the Town of Cawnpoor itself and in the buildings which are included under the head of the Terminal Works, experience and observation on the inferiority of the material used elsewhere, have led to a great improvement in both the quality of the brick and of the Mortar, a change which I consider to be due in the latter article to relinquishing as far as it was possible any dependence on purchase of lime from Contractors, and to seeing that the lime when taken from the Kiln was properly separated from the ashes of the fuel (Cowdung) with which it was burnt.

In the design and construction of Bridges I was guided by the following general rules, the leading one of which may be best explained by a diagram

1st

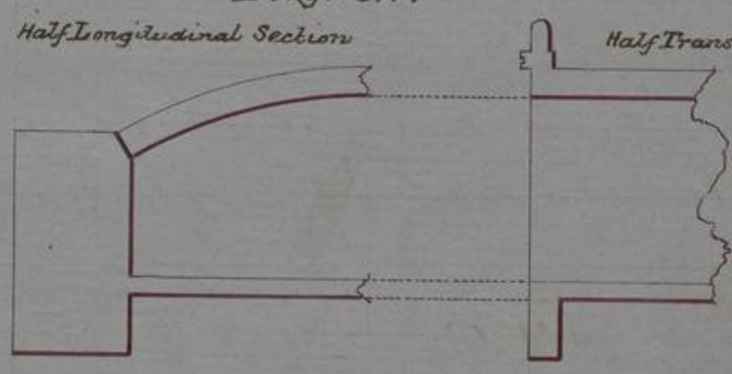
1st All Bridges to have floorings with curtains on the waterways not only for the purpose of adding strength to the work, but to act as a bar for retaining the levels of the Canal; the Section Longitudinal and Transverse being on the following design

B.94

Diag: CXV

Half Longitudinal Section

Half Transverse Section



Diag CXV.

In every case, therefore, there are 3 elements opposed to the thrust of the arch.-

1st The abutments and their back soil

2nd The Masonry wing walls of approach

3rd The floorings and curtains of the bays

2nds In all cases where the soil in which the foundations were laid ~~was in~~ was sand, Specific instructions were to be laid down - In common cases where the ground was hard and of a tenacious quality, the piers and curtains were never to exceed 10, nor be less than 4 feet in depth, the maximum measurement being only necessary in the leading 100 miles of the course of the main Trunk line.-

3rds Where the Canal bed in the vicinity of a bridge was sand, or of a light soil, the floorings were to be protected by a line of sheet piling with heavy Material laid in pume bores agreeably to the standard plan adopted in the Canal works of these Provinces, the form of this

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907

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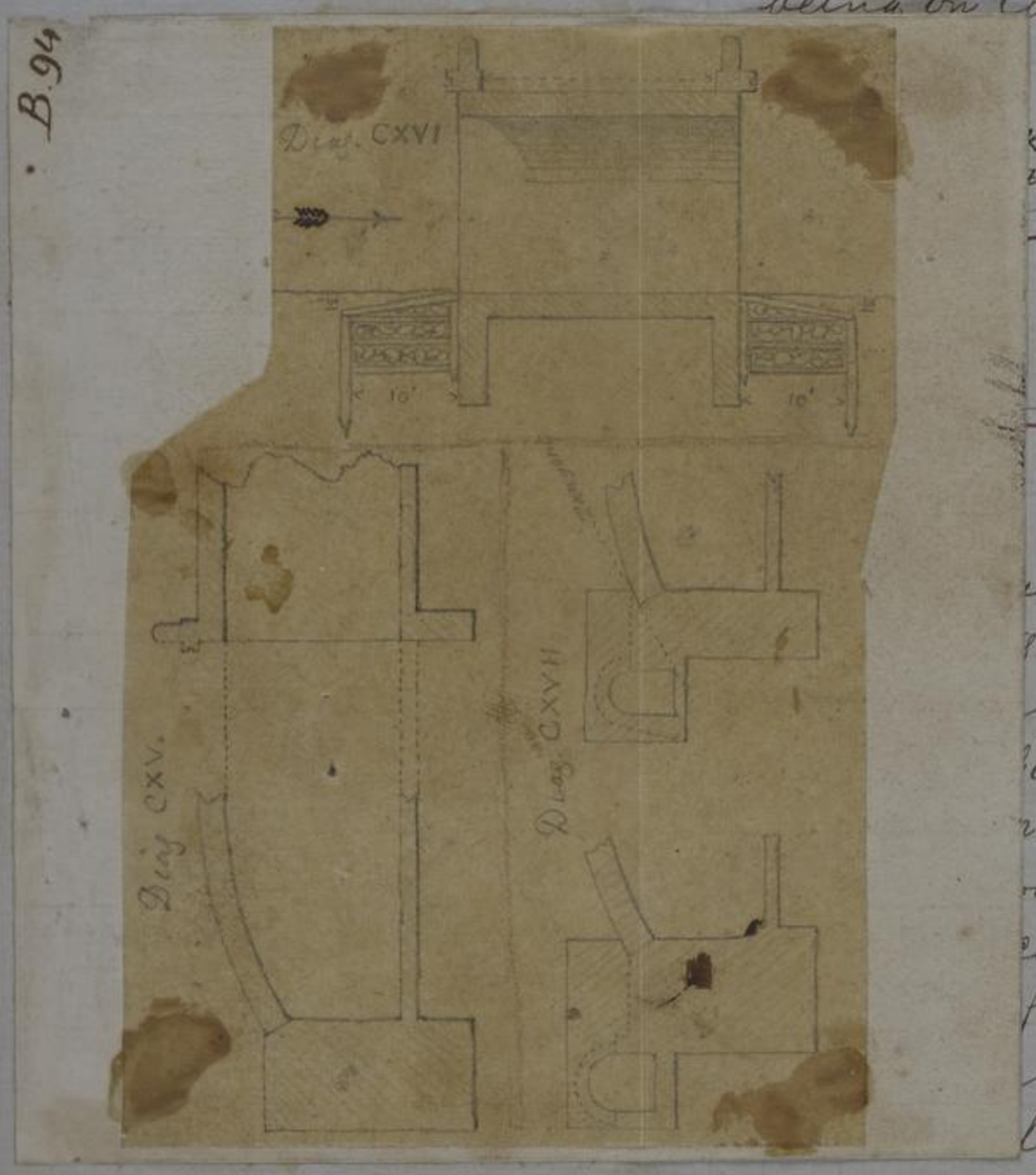
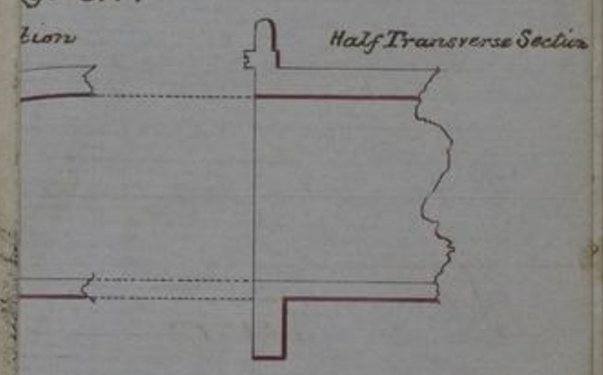


g: CXV



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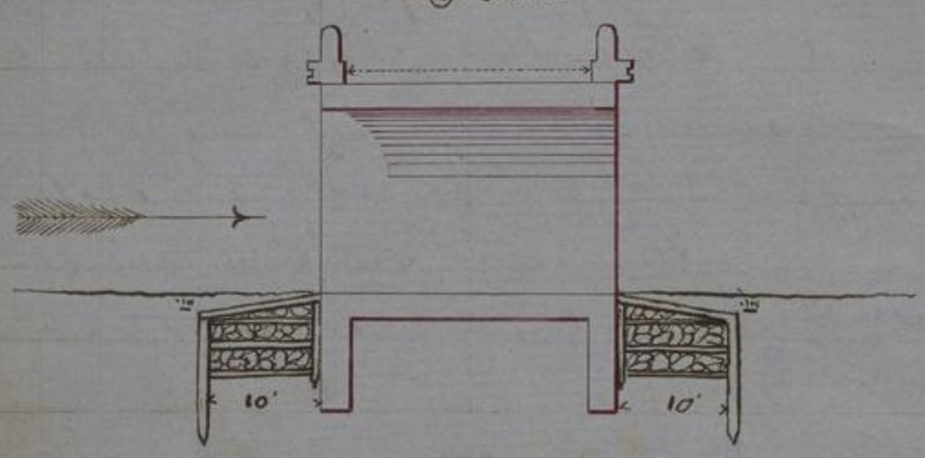
terial laid in prime bores agreeably to the standard plan adopted in the Canal works of these Provinces, the form of this

this protective covering being as follows

Diag: CXVI.



The flanks of the Canal on its meeting a bridge of this descrip-tion, were also to be protected by piling

4th. As a general rule, Arches of 60 degrees were to be preferred

5th. The Roadways were to be perfectly horizontal and to be constructed on widths adapted to the particular purpose of the line of communication. e.g.

High Military Roads to be 25 feet in width
District and Police Roads " 20 feet do
Village Do " 18 feet do

these measurements were to be the clear widths between the plinths of parapet walls, or between the brackets figured in Diagram CXVI

6th. The drainage of all Bridge roadways to be effected through the crowns of the arches by vertical cylindrical holes. —

7th. As a general rule Bridges to be built at every 3 miles in length of the main Canal and its branches, deviations from this rule to be made the subject of specific reference. —

The above are the leading points upon which the whole of the Bridges have been executed, deviations have in many cases taken place, from causes which will be

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be explained under the details of the individual works: generally speaking however, the above 7 Rules may be considered as those which have been our guide in the prosecution of all works connected with cross communication.—

It will be understood from what has been said in former Chapters that the floorings and curtains attached to the bays of bridges, are leading elements in the designs for retaining the slopes of the Canal bed, they were universally adopted in the Eastern Jumna Canal, and may be considered as the salvation of the bed of that work: from the effects of retrogression of levels, & arising from extraordinary slopes: their value as retaining bars is beyond all price. In the construction of bridges, however, they have other ~~are not less worthy of consideration, laying aside the protection to which they give from the action of a current, they provide a fulcrum opposed to the thrust of the Arch, its value as such being directly as the perpendicular depth from the impost block to the flooring and to the tenacity or goodness of the masonry of which the abutment is composed~~.—

In further illustration of Rule 1st and to the diagram appended thereunto, I will here introduce two other diagrams representing longitudinal sections, where the bridge waterways are flanked by Towing path passages.—

Diag: CXVII

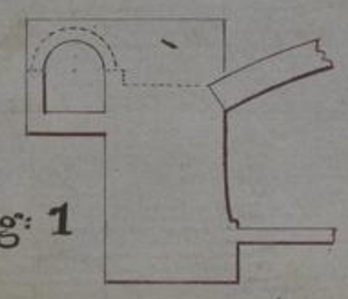

Fig: 1

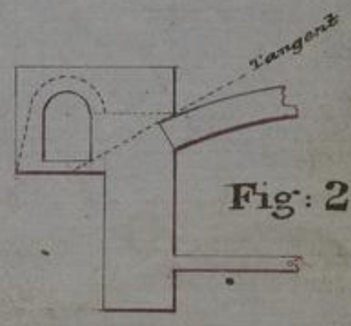

Fig: 2

ctions not less worthy of consideration
their influence in checking the action
current on the bed of the Canal. They
ide a resisting medium to the thrust
arch as exerted through the abutment
strength of which is in direct proportion
their own inertia & capacity to resist
pression. That such a medium is
important element of stability will
at once apparent when it is borne
mind that provided the abutment
of good masonry, & thus virtually
id, the value of the thrust against
floorings & curtains is in the direct
io of the perpendicular depth from the
post block to the fulcrum supplied
the floorings referred to.

Now, to give the fullest benefit to the rules of construction laid down in the above paragraph it is evident that before the Arch is allowed to exert its action in thrust, the three elements of design must be complete, that is to say in the case shewn in Diagram CXV, the bridge flooring must be built, the abutment must rest fairly and directly upon the virgin soil, and the wings of approach must be completed up to the height of the extrados. In the case represented in Diagram CXVII, Figure 2, that in addition to the requirements above stated the block through which the towing path passage is perforated must be complete in all its parts; finally that the whole of the Masonry ought to be perfectly indurated with the material which has been used on these works, a rigid attention to the above rules must inevitably have led to the most satisfactory results.

The two leading elements viz. the conjunction of the virgin soil with the abutment, and the completion of the wings up to a certain height, were easy of accomplishment, although not necessarily gained in works carried on at a distance from the Executive officer, and under the management of native mistries, or careless Overseers; the third however, or that appertaining to the floorings and curtains, was from causes which I will explain, necessarily carried out very imperfectly, and in fact to the fullest extent not carried out at all, excepting in those cases where timber centerings were used.

In

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In the construction of all arches with a Span exceeding 25 feet in width, it was my original intention to have used timber centerings; circumstances, however, connected with both economy of Time and expenditure of money rendered the Scheme impracticable; in building the Bridges on the high land below Roorkee, the great expense that would have been incurred by multiplying the centerings required for so many Bridges was a consideration of no mean importance; and the delay in completing so many arches with a limited number of centerings would have been fatal to the desired progress of the work. On the other hand the adoption of earth centerings simplified the whole proceeding, it at once reduced the expense and instantly threw over the line of works unimpeded activity. This activity of progress has enabled us not only to bring to completion works which certainly could not have otherwise been built in the time to which I felt myself restricted, but in the lower divisions where the scarcity of material has driven us to all sorts of expedients to reduce the Cubic content of Masonry, the adoption of the earthen centering has enabled us to vary the width of Span, and to reduce it to a minimum adapted to the capacity of Channel over which the Bridge is constructed.

With the exception, therefore, of the few bridges which have been built in the Khadir including Roorkee; and of the six leading

Bridges

Bridges on the high land of the Doab. Every work of this sort as described in the present chapter, has had its arches built on cen=
=terings made either of Earth alone, or of a combination of Earth and brickwork. As I have de=
=voted the leading Section of this Chapter to Centerings, I need say nothing further here, than that by adopting the cheaper and more expeditious plan offered by Earthen centerings, we were prevented from building the floorings simultaneous=
=ly with the piers and abutments, and have, consequently, in such cases, failed in completing the necessary elements required in Rule 1. —

It will be observed in the Section on Centerings that where the soil was of a good and tenacious quality, the piers and abutments were laid in up to the terreplein or natural surface, the interme=
=diate ground or that occupying the site of the bay being left in its virgin state to act as a supp=
=ort for the Segmental superst=
=structure required for building the arch upon. — Until the arch was built, therefore, and until the time for removal of the centering had arrived, the ground occupying the bay had literally not been touched by a Spade. it necessarily followed that the flooring and Curtains of which the Substructure consisted were, instead of being the first, the last portion of the building executed. —

Again in Sandy tracts where it was necessary to remove all

924

all the soil, and in laying the foundations to great depths to excavate with wide and extended slopes; where in fact the whole of the foundations were laid in a crater, which was after the completion of the walls filled in with loose sand; although the curtain walls were built, it was not thought advisable to complete the floorings, until the subsoil was sufficiently compressed.. The floorings therefore, were delayed until the Earthen centerings were removed and until the thrust of the arch had been brought to act upon the abutments: in this case, however, the 3rd Element although not complete in all its parts, was present in the curtains or lines of foundation wall which give the tie or bond between the up and downstream sides of the Substructure: it was incomplete solely in the flooring itself.- It will be understood, therefore, that Timber centerings have been confined entirely either to the works in the Ganges Khadir, or to the few bridges in its immediate neighborhood, whilst by far the greater proportion of the Bridge arches have been built either with centerings of earth, or of a combination of material of which earth is the predominating ingredient.

The second and third rules have been I believe in all cases explicitly followed. In the Khadir Bridges of which there are only two that come specifically under the present description, the Kunkhal Bridge is laid in boulders to a depth

of

of 8 feet, and that at Dowalapoor in a mixed soil to a depth of 8½ feet; in both these cases the third rule for protecting the head and tail has been rigidly attended to — On the high land from Roorkee downwards, as far as the 110th Mile including the bridge at Raoli, the Foundations vary in depth agreeably to the nature of the soil in the early part of the course of the Canal where it passes through the Muzuffurnuggur District, and where sand predominates the depths of foundations is never less than 10 feet. that of the works connected with the falls it will be recollected is on one case equal to 32'5 feet; in all these cases, however, the floorings are well protected The soil below the Mozuffurnuggur District and in the ~~upper~~ part of that of Meerut is of a better quality, in the latitude of Meerut, however, we get into the region of Springwater, and into depths of foundations depending very much upon their level — From the Raoli Bridge above mentioned, however, and throughout the Bolundshuhur and Alleegurh Districts, the soil although in many places at a small depth below the Canal bed of pure sand has not forced upon us the necessity of maximum depths of foundations, but in all doubtful cases, and wherever there appeared to be a probability of current action near the Bridge floorings, these portions of the works have been most carefully protected. —

925

On

926

On the Terminal lines, the soil almost universally is hard and tenacious, the depths of the foundations in no case exceeds six feet, and generally it is only four; the excellence and hardness of the soil ~~have~~ has moreover (in the difficulties under which the Executives labored in procuring Materials for building) in many cases led to the whole of the superstructure being built on a platform of Masonry equal in thickness to that of the floorings, the foundation or curtain walls on the up and down stream sides being alone sunk to the standard depth. On these lines also protective aprons are given on the rule prescribed in all cases where such appears to be necessary. As a further to guard against accidents, and that we may anticipate, rather than be unprovided on emergency, every bridge, in fact every Masonry work connected with the Canal Channel, is supplied with a magazine of heavy material, either in the shape of boulders, blocks of Kunkur, or, in their absence, of Cubes of Masonry. At each of the bridges on the Ganges Canal works, 10,000 maunds or 350 Tons, of this species of material are present on the spot, to secure an immediate remedy in case of accident

The 4th Rule which prescribes a particular form of arch has generally been adopted. Even in cases where the Elevation is elliptical, the construction is on a

a simple segment equal to one sixth of the Circle;- in most cases the segment is externally shewn; it enables us to give excess of height to the piers, and thereby to offer facilities for the passage of boats at high water - To the builder and accountant, moreover, it simplifies calculations of Cubic Content - The only deviation from the 60° arch is in a set of bridges built with small brick which will be described in their proper place, the increase of rise and the expanse of spandril gained by the shorter radius having in my opinion no great beauty to recommend them.

Rule 5 has been acted up to in all cases, and I wish that many of the bridges in anticipation of the lines with which they are connected becoming 'High Military 'Roads' had been designed accordingly - In the upper parts of the canal where the width of Channel is equal to nearly 200 feet a roadway contracted to a width of 18 feet is exceedingly inconvenient, whereas in the narrower parts of the Canal such a width of roadway would be sufficient for all practical purposes; to lay down a general rule, therefore, for width of roadways on bridges built under different circumstances was ~~perhaps unwise~~ somewhat inconvenient, although in doing so, economy in cost was consulted, as an additional foot even in width ~~in many bridges~~ would have added largely to the Estimate. In the District of Campoor where the Bridges which cross the Canal consist of 1 and 2 arches only

V
And in some of the smaller arched bridges in the Campoor Terminal line;

928

only, and the maximum width of the Canal Channel at its intersection does not exceed 70 feet, the Bridge roadways have been made on a width of 15 feet only, but it cannot be too often explained, that the extraordinary and unusual difficulties in procuring Material of all sorts, (especially brick) in the Canon for Terminal line from the 108th Mile downwards, led to the reduction of the dimensions of all works to limits which may be considered extreme.

With regard to drainage the plan laid down in rule 6, has been in all cases adopted - by perforating Cylindrical holes of 4 Inches in diameter through the crowns of the arches on both sides of the roadway: this gives a very efficient relief, even in the heaviest falls of rain to which we are subjected. —

Very considerable modifications have been made in the 4th Rule, which as is implied, was more intended as a general one for guidance, than for adoption in its strictest sense; practically speaking, Village Roads have been, as far as such could be managed with propriety, limited to distances of 3 Miles apart, but in all cases where the cross communications of the country would have been in the slightest degree interrupted by such an arrangement, it has been freely deviated from: this is more remarkably shewn in the proximity of Towns and in the richly cultivated Districts lying below the Nanon

regulations

Regulators, but even in the main Trunk line, where the extent of works for cross communication and their cost ~~which their magnitude entailed upon the Estimates~~ naturally called for a judicious although restricted disposition of works of this sort, bridges have been built at all points where such were absolutely necessary, without reference to the especial rule, on which I am now remarking.- In looking at the Map it will be observed, that the longest tracts of the Canal unbridged, exist in the Saharunpoor and Mozufurnuggur districts between Roorkee and the Mudnoodpoor Falls in one case, and between the latter work and the Falls at Chitowra in the other; the apparent deficiency of Bridges in this neighborhood arises more from their distribution, than otherwise; the Country above Chitowra is very imperfectly cultivated, it is generally speaking much Elevated, Sandy, and in its present state adapted to the growth of rain or Khurreef Crops only: this is remarkably shewn in the Muzufurnuggur District but it is more or less common to the whole tract. In building our Bridges therefore, their sites were determined at points most convenient to the Towns and Villages in the neighborhood; in some cases it will be observed, at distances apart from each other considerably less than that laid down for our guidance. In the Mozufurnuggur tract the disposition of these works is adapted

in

930

in my opinion to meet even future wants; that in the Saharunpoor District when the Cultivation is of a better description may be improved by additional bridges built at points equidistantly between the Roorkee Aqueduct and the Assoffnuggur falls, and between the Libenhen Bridge and the Falls at Muhmoodpoor. At both these points my Estimate of 1850 includes the abutments of suspension or lattice bridges; an idea which has been extended by building the substructure and abutments on the same design as that of the Masonry bridges already constructed viz: of 3 bays of 55 feet each, with piers of 7 feet in width, giving a space between the flanks or side abutments of 179 feet - to these works floorings and curtains have been added, so that we have the means ultimately of completing them as arched structures, for a plan which I strongly recommend. We at the same time have this arrangement added to the Canal bed two more retaining bars for the maintenance of the slopes -

P. V. ii

Where every additional check to re-
-trogression of levels, is of the most
extreme importance: the impra-
-ticability of extending the Masonry
works, however, at Roorkee and its
vicinity beyond those of direct
necessity arises from the Aqueduct
works absorbing every brick that
could be made, and it was with
the greatest difficulty that Material
in Sufficient abundance could
be procured for completing the
Asoffnuggur works. - The con-
-struction of these works has been
constantly interrupted through a
Period of no less than Years,
and it is only within the last
year that progress to the extent
of preparing the Main Channel
for the reception of the water, whilst
the Locks and works appended
thereunto have been left in abey-
-ance, has been carried on with
any degree of steadiness. - To
build the floorings and abutments
of an additional bridge in the
midst of such an overwhelming
demand for materials was quite
out of the question, and although
the value to the bed in the exist
-ence of an additional retaining
bar would have led me willingly
to meet the wishes of the Civil
authorities. and although it
is evident that every additional
bridge gives increased means of
cross communication. I am by
no means satisfied that there
is any peculiar hardship as far
as the Cultivators are concerned
in a bridge not having been built
at this particular Spot. for the
Country

~~County at large there can be no~~
~~inconvenience, and were district~~
~~roads made to bear upon the~~
~~Roads and to ~~[illegible]~~ bridges,~~
~~the ~~[illegible]~~ ~~[illegible]~~ would~~
~~be ~~[illegible]~~ complete ~~[illegible]~~ ~~[illegible]~~.~~

In fixing the sites of Bridges for high Military and district roads, every attention has been paid to the wishes of the local Committees in whose hands the funds for road making pur=poses are placed; on the other hand the Committees have in all cases responded to the wishes of the Director of the Works, in connecting the Cross and village roads with those bearing upon the bridges; in making Roads to meet the Bridge approaches where such did not exist before, and in giving to intermediate estates, or to those whose boundaries lie equidistant between 2 Bridges, free and open communication with their ap=proaches. A great deal of this most useful and necessary part of the undertaking has been com=pleted, or is in progress at the present time; it is in full vigor in the Muzzuffurnuggur, Meerut, Bolundshuhur, Etawah and Allygurh Districts, in which both the Civil authorities and the Road Commit=tees have been as anxious to give the means, as the Canal Executive officers have been to carry out the works. It is most backward in the Saharunpoor District, although in the early years of the progress of the works a good deal has been done in the neighborhood of Dowalleepoor and Hurdwar=

2, 225; V. ii. pt. iii. ch. iii.

from

From Roorkee to the Southern limit of the district, which includes the aqueducts of Nuggur, Munglour, Libunhee, and Muhmoodpoor Tall bridges, no work of the nature alluded to, has been yet commenced; the Bridges therefore are isolated and are only useful to those whose Estates impinge on the track that leads to them.

The design of the Bridges has been regulated by two considerations somewhat antagonistic in their requirements; viz: the necessity of giving a sufficient height to the Doab above high water mark, to admit of the free passage of craft and at the same time an equal necessity for placing the roadway at a moderate height above the level of the Canal that the ramps of approach may be conveniently elevated.

These two requirements have been given two parallel lines, separated by a minimum height to which the elevation has been necessarily restricted.

In cases where the depth of water was great, the distance between high water mark and the top of the embankments was sufficient to obviate the difficulty arising from the causes above mentioned, and in such cases elliptical arches have been almost universally used. Elsewhere the required span has been gained by raising the level of the Piers and adopting a flat segmental arch, by which as much passage as possible is given to the passing stream on the whole width of the waterway. Passages for the convenience of access to different parts of the building in connection with Towing path passages and Irrigation have been considered as necessary part of the design.

In elevation has been made as simple as possible, and limited to as few varieties as the nature of the works would admit of; with the Exception of the Bridge at Peeran Kulleen which from its position and height of roadway from the bed of the Canal required a specific design. The whole of the bridges may be separated into 5 Classes and placed under the following denominations viz:-

1st Class. Elliptical arches with niched pilasters, vide pattern Plate XLIX, Atlas

2nd Class. Segmental Arches, with niched pilasters. vide pattern Plate L, Atlas.

3rd Class. Segmental Arches. with open arched Spandrils. vide pattern, plate LI Atlas

4th Class. Segmental Arches. with Spandrils pierced by Cylinders and with the towing path passages marked by rusticated pilasters; vide pattern, plate LII Atlas

5th Class. Segmental Arches. plain vide pattern, plate LIII Atlas.

To these numbers I shall refer

refer in the detail of the different
works, noting opposite each, any
deviation that may occur from
the Specification above mentioned
To commence, therefore, with:

ii. Bridges between the Head of the Canal and Roorkee

The greater proportion
of the ~~works of this sort~~ Bridges which are
built in the Ganges Khadir, are
connected with the Myapoor and
Dhunowri Dams ~~Heads~~, and with
~~this~~ works
~~Head~~ attached to the Solani Aque
=duct. There are only three which
fall specifically under the head
of the present chapter, and which
as being disconnected with the
great works above mentioned, and
having no connection with Regu
=lating either Supply or Escape,
may be classed as works of Com
=munication merely. The three
Bridges which fall under this de
=nomination are

1st The Kunkhul Bridge
2d " Jowalapoor do
3d " Peerankulleeur do

The Kunkhul and Jowalapoor
Bridges are of the 1st Class, their posi
=tion is opposite to the Towns from
which they take their names and
they are provided with roadways
of 18 feet in width. These Bridges
have 3 Bays of 55 feet each, with
intermediate Piers of 7 feet. The
roadways are in both cases ele
=vated 24 feet above the bay floor
=ings, the latter being protected by
Piling and boulder work, and
the upstream and downstream
flanks being covered by flights of
Steps or Ghats for the convenience

of

of Travellers.-

The Ghats attached to the Dowlaporr Bridge are designated the "Dalhousie Ghats" in honor of the Governor General by whose orders they were constructed on the application of the Inhabitants of the Town when His Lordship inspected the works in December 1831. To the left upstream flank of the Dowlaporr Bridge the Navigable Channel Head is attached.- With the exception of the foundations and the massive parts of the abutments, the whole of these works are built with brick ma-sonry, with an external coating of Stucco.

Timber Centerings on the Plan shewn in ~~Sheet~~ to Gate LXII Figs 1 & 2 of the Atlas were used in the construction of the arches; and the cement used was as follows:-

1 Part Stone Lime
1 " Sookee
1 " Sand

The quantity of material used, and the rates of building are shewn in the following Table.-

Bricks — 12" × 6" × 2½	1055396			
—Do. — 12" × 6" × 2"	265702			
Boulders ———	120819	Maunds		
Stone Lime ———	56174	Cubic feet		
Sookee ———	63687	do		
Masonry of all sorts	15	3	6	p 100 Cub ft
Plastering	7	6	10	p 100 Sup ft

The Total cost of each of these works is shewn by the following detail

Kunkhul Bridge	25853	6	3
Dowlaporr —do—	39242	9	11

They were built by Mr Kay, Assistant Engineer

936

Engineer of the works.

The Peeran Kulleem Bridge is for the passage of the high road between Tahanumpoor and Burdwan, it is situated near a Durgah and Mahommedan Shrine, where there is an annual fair at which a large concourse of people is assembled. From the circumstance of the Canal Channel at its point of intersection by the bridge being of extraordinary depth, it was necessary to vary the design accordingly. its proximity to one of the leading places of assemblage on the route to Burdwan also, and the necessity for providing towing path passages on the lower levels for the use of the railway between Roorkee and the Dhunowri works led to further deviations from the standard plan of bridge that was proposed for the Khadir works

The Plan, Sections &c. of the Peeran Kulleem bridge are figured in Sheet XXVI of the Atlas. its waterway is similar to the bridges at Kunkhul and Jowalapoor viz: 3 bays of 55 feet in width, the piers are 8 feet. The arches are segmental (60°) supported on rusticated pedestals, terminated by a flat pyramid, the side of which meets a "Corne de vache" or bevel to the face of the arch. The side towing paths or railway passages are 12 feet in width and 15.77 feet high from the roadway to the soffit of a flat segmental arch which covers them. These passages are flanked by rusticated work carried to the height of the piers with which they architecturally correspond. A plain shield

Shield is placed over the arch of each of these passages. Above this, ~~the face of the bridge is ornamented~~ is with a simple block cornice or double lines corresponding in character with the rusticated pedestals, the whole being crowned by a plain parapet wall. The height from the flooring of the bays to the bridge roadway is equal to 36¼ feet. ~~Excavations beneath the surface of the boundary, or outer edge of the foundations to regular depth.~~ On the down stream flanks of the bridge, flights of steps lead to the berm, from whence there are Ghats for bathing purposes. On the upstream side, the bridge flanks are protected by wings

Spring water which at the site of the above bridge existed on a level 12 feet above the bed of the Canal; and which after the Channel was opened, was maintained at moderate depths only by the use of machinery, led to a necessity for block sinking for the foundations of the Piers and Abutments; The blocks for this purpose were undersunk to a depth of 10 feet, and the substructure connected with them was arranged on the usual plan. The floorings of the bays were laid in to a depth of 2 feet with up and down stream curtains equal to 10 feet in depth. Both the floorings above described, and the flanks of the bridge, as well as the fronts of the lines of Ghats are protected by aprons of piling and boxwork. The exterior of this building is Stuccoed.

Although

Although Segmental, the arches correspond so far with the Elliptical curve of those before explained, that with a slight alteration at the haunches, the timber centerings which were in use in the Khadir works, continued their services at the Peerankulleem Bridge.-

Brick Masonry was alone used in this building, with mortar of the following proportions

1 Part Stone Lime
2 - Doorkee

938

The quantity of material expended and the rates of the work were.

Bricks — 12" × 6" × 2½		756800				
— Do — — English measure		285090				
Stone Lime —		17242				Cubic feet
Doorkee —		34892				a —
Masonry — Plain —		19	5	9	p.	100 Cubic ft
— D. — Arch —		32	14	5	p	a —

The cost including both bridge and Ghats amounted to Cos Rs 35307 .. 14 .. 0 it was built by Mr Parker the Assistant Engineer attached to the Aqueduct works.—

Although the 3 Bridges above described are placed by themselves in the present chapter, it must be borne in mind that those which are included in the great works attached to the Khadir are equally efficient for the purposes of cross communication— The tract of Canal included in the present section is 19 Miles in length; in which independently of the superpassages for the Ramipoor and Puttri Torrents which when floods are not running offer the freest possible passage for the herds of cattle which graze in their neighborhood, there are besides the 3 bridges above enumerated

Enumerated

1 Regulating Bridge at Myapoor
1 Bridge at No 2 Falls
1 Do at " 3 do
1 Cross Bridge at the Rutmoo Works
1 Regulating Do Do
2 Bridges at the Solani aqueduct

so that there are no less than 10 bridges, besides the Superpassages, making a Total of 12 lines of cross Communication over the Canal Channel in a length of 19 Miles.—

iii Bridges between Roorkee and the Nanoor Fork.—

On this line which constitutes the main Trunk of the Canal in its progress from Roorkee where it enters the high land of the Doab, to the Nanoor regulators at which point the Trunk is separated into two branches, the bridges with one exception are on the uniform design of the four leading classes under which they may be placed numerically in the following order

1st Class	7	Bridges with	3	Spans of	55 feet each
2d do	14	do	3	do	45 feet do
—	8	do	3	do	40 feet do
3rd do	5	do	3	do	35 feet do
4th do	10	do	3	do	30 feet do
———	1	do	Supernumary at Sirdhanna		

The designs for the 1st Class has been described in the former section under the head of the Kunkhul and Dowalapoor bridges, ~~of~~ which ~~three~~ are patterns, ~~of all the bridges of the~~ for the works now under description; they have towing paths (in which respect they differ from those before described) attached to the left flank of the left bay; consisting of a timber platform supported

supported on uprights which cause no impediment to the free passage of the water through the bay. The waterway and the height of the Bridge Road from the bed of the Canal are similar to those in the Khadir, with the exception of the bridge at Mungloun where the latter is 25'5 feet. - At the village of Mundoli or equidistantly between the Sibunhein Bridge and the Much moodpoor Falls, and at Gurespoor South of Rookee the substructure and Abutments of ~~Bridges~~ on Class No 1, have been built as I have before explained for ultimate purposes, ~~as to be~~ completed as arched ~~Bridges~~ Bridges.

Gurespoor

Plumb

The Soil on all the country as far as the 110th mile is of a very loose and sandy description, which has led to the necessity of protective measures being taken for the preservation of the floorings and flanks of the Bridges & At those of Mungloun Moradnuggur and Shelpulhera Liburkheri, Dimat, Jansut, Khutowli, Sirdhanna, Nanoun Ghats have been constructed which whilst providing the means of access to the water, give good protection to the Channel on its approach to the bridges. The Khutowli Bridge which lies at the 62nd mile and is similar in design to that at Mungloun Liburkheri & others of Class No 1 ~~Bridges~~, has a roadway of 24 feet in width, to adapt it to the purposes of the High Military Road between Meerut and Saharunpoor to which it affords a passage over the Canal. - Ghats and means of approach to the water are here designed on a more elaborate scale than elsewhere; they are situated on the downstream side of the Bridge, to which they are

attached

attached, whilst the upstream side is protected in the usual way by flank curved revetments. For a detail of the different bridges with the works attached to them, reference can be made to Part II in the 2nd Section of the 2nd Chapter of which a full description is given: and there appears to be no necessity to encumber the text with a detail of material and rates of each work, when the whole can be found by turning to the Table J in the appendix. It will be sufficient in this place to note, that the Bridges under No 1 Class which are included in this Section are built of brick masonry, with Cement made of Lime and Sookhi (pounded brick); that they are all stuccoed externally, and that the roadways are metalled with Kunkur. Their approaches from the Country are by ramps or inclined roadways laid out on a Slope of 1 in 50.—

The average rates per 100 Cubic feet of Brick Masonry on the above works may be estimated at Cos Rs 11.. 7.. 1; and the average Cost of a Bridge without Ghats at Cos Rs 2312.. 10. 8 —

The depths at which the foundations of the different bridges were laid will be seen by reference to Plate XLIX of the Atlas. —

Amongst the Bridges which under the 2nd class are those ding from Kaupulpera at the 106½, to that at Sheka at the 177½ Mile; the whole of the bridges from the 106½ Mile to the termination of the Main Trunk being built on the same general design

947

design.-

With the exception of the Bridges at Ravli, Pepulhera, Dhumkoora and Uchuhja; they are connected with the heads of Rajbuhas and Inlets as shewn in plate L of the Atlas. In the Ex-=ceptional cases, wings and short lines of Ghats are attached either to the up or downstream faces of the work and in some cases to both.

There are 2 descriptions of waterways viz: One having 3 bays of 45 feet each, of which the Bridges from Peepulhera to Tulwenda are examples, the other having 3 bays of 40 feet each in width: of the former there are 14 bridges, of the latter there are 8.-

These Bridges have in all cases their waterways flanked by side arched passages 5 feet in width pierced through the wings, in pro-=longation of the towing paths, by which an uninterrupted passage is maintained along the berm. Con-=nected with the Heads of Rajbuhas which lie on the upstream side, are lines of Ghats with a platform and retaining wall for the purpose of giving access to the water; of giving free space for the apparatus required for regulating the Rajbuha Head Sup-=ply; and also for protecting the Rajbuha Head from inconvenience which would inevitably arise, were it in close proximity to the Earthwork. At the Bridges at Moongla Khya and Nagsimpoor Nirwah and Wullipoora, over which the great roads of the Coun-=try cross the line of Canal, these Ghats are extended to a length of 350 feet, bearing upon the Bridge flanks in an Ogee Curve,

and

and approaches from the higher levels of the Roadway embankments by flights of steps. The berm platform is reached by steps appended to the wing walls of the bridges, ~~similar~~ similar steps being provided at the Inlet and Rajbaha Escape. On the down stream side, the Bridge is usually terminated by plain curved revetments sweeping into the Earthwork. In some particular cases, however, at the Dumkoora and Uchukja Bridges for instance flights of steps or Ghats, giving access to the water from the berm levels, have been added, offering additional facilities for approach to the Canal Stream - In all cases where such has appeared to be necessary, protective aprons to the walls lying in contact with the current have been adopted; in the Bolundshuhur and Aligunj Districts where Block Kunkur is abundant, this species of Material has been substituted for the piling and box work which is used in the Northern Districts

The facilities with which Block Kunkur has been procured at all points through which this series of Bridges extends, have led to its adoption to a very great extent for building purposes; with the exception of archwork nearly the whole of the Bridges now under description are built entirely of Kunkur, and in the case of the Kasimpoor Bridge the external faces of the arches themselves are made of this material

The design of Elevation differs in no respect from that which I have placed in No 1 Class excepting in having a segmental

instead

instead of an Elliptical arch, and in having a curved batter to the perpendicular faces of the Piers, Abutments, retaining walls, &c.w, From the reduced depth of the Canal Section, and the height from the roadway to the bay flooring being only 19½ instead of 34 feet, the proportions of these bridges are better than those of the works in the upper District, there is greater harmony between the parts, and their general outline is more agreeable to the eye, than the more elevated structure, buried as it were between enormous embankments Where brick has been used, as in the arch work, and occasionally in other parts of the building, the material has been burnt at our own manufactories in the Pirzawa or native Brick kilns; the size of Bricks, viz. 12" × 6" × 3" and its quality excellent.—

A detail of all these works with their appended Shuts, &c.w, will be found in the 2nd part: and that of the material expended, rates &c.w of each separate Bridge form part of a Table in appendix J which is especially drawn up, for the purpose of giving the fullest information on the subject.—

The description of class No 2 requires no further illustration than that the exterior of the Bridges is stuccoed, and that the cement used consists of

1 Part of Kunkur Lime, to
7/20th of White Stone Lime.

The roads of approach both from the Country and from the Canal Embankments, are laid down on an uniform slope of 1 foot in 50 excepting

Excepting on the Grand Trunk Road where this has been diminished to 1 in 100: the roads are metalled with Kunkur, and where the Ramps of approach are much elevated, their sides are turfed, or in other words planted with Doob Grass.-

The average rates per 100 Cubic feet on which the bridges of this Class have been constructed may be estimated as follows:-

Arch Masonry	per 100 Cubic feet	14	9	..
Other Do	Do	11	.	8
Plastering	per 100 Square feet	2	3	4

And the average cost of the Bridges at

Rs 10920 : 10 : 1 each for 135 feet Water Way
10502 : 14 : 1 - do - 120 feet - do -

The depths at which the foundations of the different bridges are laid are exhibited in Plate L Sheet 3 of the Atlas.-

Of Class No 3, there are five Bridges only, and these are entirely confined to the line of Canal lying between the Futtiguhr Branch Head and the Town of Sidhaura, or more properly between the 53rd and the 71st Miles, at which points the Bridges of Dukheir and Utterna both of which belong to the above class, constitute the 2 extremes of the series. The design was dependant on the material, which consisted of small bricks varying in size from 4"x3"x1½" to 9"x3½"x1½" procured from numerous old ruins purchased in the neighbor-hood, the most prolific source being an extensive Quadrangle or Serai at the Town of Chitoura. These ruins consisted of the small brick above adverted to cemented with

with mud, an ingredient difficult to get rid of when applying the brick to the new work, and which undoubtedly might have been dis=pensed with with great advantage. The Bricks, however, were washed and cleaned before they were placed in the works, and whatever might have been their defects they were of the greatest aid in accelerating progress. To meet the material in question it was considered necessary to extend the segment of the arches beyond the standard limit of 60°, as it was supposed that with an increased versed sine or rise there was less risk of failure from the contingency of bad brick laying. The versed sine there=fore, was increased from $\frac{1}{7}$th. of the Span, or that (nearly) which is due to an arc of 60° to $\frac{2}{11}$ths. or to a height of 10 feet. The expanse of Spandril caused by the rise of Segment, was broken by a se=ries of arches perforated through the bridge and occupying the whole Space bounded by the extrados of the arches and the line of Cornice. The parapets were in open rail work, the diameter of the pillars corres=ponding with that of the small brick with which we had to deal. Towing path passages six feet in width were designed on each flank of the main arches, their approaches being covered by curved revetments, or as in the case of the Sans at Bridge by lines of Ghat. The Bridge borings are fitted with steps on their concave or outward side for the convenience of descent from the roadway to the Towing path levels. The bay floorings and the

the flanks were protected by piling and apron work where such has been considered neces-sary, and nothing has been neglected to render the substruc-ture secure from the effects of the current.—

The Roadways of the 3rd Class Bridges are elevated 24½ feet above the bay floorings, they are metalled with Kunkur, and drained by vertical holes through the crowns of the arches. The ramps of approach from the Country are made on the usual slope of 1 in 50.—

A detail of all these works will be found in the Table in appendix J before referred to, which will give all the necessary items of expenditure and rates The cement consisted of

2 Parts of Earth Lime
1 —a— Sp Sorkee

and the bridges are externally stuccoed

On an average the rates per 100 Cubic feet are equal to Cowrans Rupees 12 . 15 . 3

and the average cost per Bridge without Flats may be estimated at Co Rs 18636 . 3 . 8

The depths of the foundation are shewn in Plate LI of the Atlas

Of CLASS 4, there are ten bridges; extending from the 77th to the 103rd Mile, or from the Nanoor Bridge or that below Sindhanna to the Bridge of Noorpoor a village situated below the High Military Road connecting Meerut and Delhi

the

The waterway of these bridges is divided into 3 Bays of 50 feet each in width, separated by piers of 6½ feet. The arches are 60° Segments. The Spandrils are perforated by Cylinders which pass through the work, their up and down stream fronts being finished by a Coped or bevelled facing. The Cut waters which terminate at the Spring of the Arch are plain segments meeting in a point towards the Stream. The faces of the Bridge are quite plain. On each flank and in prolongation of the Towing path is a passage six feet in width, maintaining a free line of communication along the berm. these passages are flanked by Rusticated pilasters. The long walls of the Bridge or those which open out towards the Country, are fitted with flights of steps to give access to the berm from the top of the Embankments. The whole is crowned by a Cornice and parapet on the usual standard dimensions. Plans and Sections of No 4 Class bridge will be found in Plate LII of the Atlas

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As a detailed description of these works, shewing the precise nature of their appendages in the way of Ghats and flanking defences is given in the 2nd part, and as the Table in appendix gives full information on material, I need only remark in this place, that the same attention that has been given elsewhere in the protection of floorings and sides wherever the bed of the Canal was of a nature

nature requiring such protection, has been given with an unsparing hand to these works. At the Moradnuggur Bridge which is situated on the High road between Meerut and Delhi, a series of Ghats similar to those which have been built at Khutowli have been attached to the down Streams side of the work: to the upper side, protection has been afforded, as at Khutowli, by wing Revetments.

The foundations and the nature of the soil in which they were laid will be understood by reference to plan No LII Spring water was frequently met with on this line of works at moderate depths

The roadways of approach as explained before rise gradually from the surface of the Country to the levels of the Bridge road on a slope equal to 1 in 50, the bridge road itself being metalled with Kunkur. Drainage is here, as elsewhere, obtained by holes through the crowns of the Arches. The height of the Bridge road from the flooring of the bay is 19·75 feet.

The works included in this class are entirely built of brick Masonry, the cement which was used being either Kunkur Lime alone or Earth mixed with Surkhi Lime, in the following proportions.

2 parts of Earth Lime
1. do of Surkhi (pounded brick)

they are Stuccoed externally agreeably to the usual practice on these works.

The average rate per 100 cubic feet of Brick masonry may be considered as Rs 12 " 9 " 8.—

and the average cost of each Bridge without Ghats as Rs 14403 .. 12 .. 4

The only work that remains to be described on the Section extending from Roorkee to the Nanoor Regulators is the Sirdhanna Bridge, which like that at Peerankulleen described in Section I is a solitary exception from the Standards enumerated under the 5 Classes.— This Bridge is on the high road between the towns of Meerut and Sirdhanna, the waterway consists of 3 bays of 55 feet each in width its arches are elliptical. On each flank of the bays are towing path passages the floors of which being raised above the towing path are six feet in width: The design is in fact a composite one the body of the work resembling in all respects No 1 Class, the flank passages being similar to No 5 From its position relatively to the Town of Sirdhanna, Ghats similar to those at Khutowli and Moradnuggur have been attached to its down stream face; to the above two bridges it assimilates also in its upstream flank protections, and to those of the floorings— with the exception of towing path passages the whole work is a close representation of that at Khutowli.

In the finish of approaches roadways and all minor points in external appearance this work corresponds with those above described. Its foundations are limited in depth to the spring water surface which lies at a depth of six feet below the bed of the Canal; they are protected both on the up & down stream faces by a double line of piles, the intermediate spaces being filled with large masses of block kunkur. The flooring is probably the weakest portion of the Bridge both on the up stream & down stream face by aprons 8 feet in width extending from one side of the channel to the other.

The Sirdhanna Bridge is built with brick and lime Cement consisting of the following ingredients

2 parts of Earth Lime
1 Do of Sonkhi

and it is externally stuccoed.—

The rate for 100 Cubic feet of

of Masonry is on an average
of the whole work Rs 13.. 5.. 5

and the Total cost of the Bridge
was. Company's Rupees
31571.. 12.. 0

In the Section which I have
just described and which embraces
a series of works on a line of 161
Miles - the Chane independently
of the bridges above enumerated,
which amount to 45.
10 Falls, the heads of which are crossed by
Bridges
4 Regulating Bridges at the Heads of
Branches
giving a total of 59 points at which
the Canal may be crossed by the
public. In addition to this, prepara-
tory measures have been taken by
laying in the Substructure previously
to the admission of water for the
building of ~~two Locks~~ Bridges at the
villages of Mundowlee ~~and Mohumpoor~~ Gunesh poor
~~Locks~~ with
59 Bridges, however, on the above
distance of 161 Miles, we obtain an
average of 2.72 Miles between each
bridge, which by completing ~~those Locks~~
at Mundowlee ~~& Mohumpoor~~ Gunesh poor will
~~be~~ be diminished
to 2.63 - with roads well laid out,
and brought to bear upon the Bridge
approaches, by lines radiating from
the villages and Estates lying inter-
-mediately between the bridges;
and in cases where Estates are in-
-conveniently separated with the
aid of the Civil authorities in
making equitable adjustments
in the land so separated, the
number of Bridges now built
will I doubt not be sufficient
for a long time to come. —

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IV. Bridges on the Termini Lines between the Nanoor & Tork, and the Ganges and Dumna.

This Section includes the whole of the bridges which lie between the Nanoor Regulators and the Heads of the Terminal works: i.e. in the case of the Cawnpoor Terminal line to the Dubowlee Escape in that of the Etawah line to the Escape at Moosanuggur with very slight modifications and those only in a few instances to which I shall draw especial notice, the whole of these works belong to the 5th Class; the whole of them moreover would have been on one regular graduated system of water way (i.e. no arches exceeding 33 feet in width, none less than 20) had circumstances arising from difficulties in procuring material in the Cawnpoor Terminal Line, not interrupted it. — I may observe however that throughout the whole of the works the design of Inlet and Rajbaha Channels, with their facings, is with very few exceptions universal; the few cases in which these appendages have not been built are consequent on the inapplicability of the site for the purpose. It will be understood, moreover, that the rules for bridge building which I have explained in the early part of this Chapter, were here, as elsewhere, in full force. — With these few remarks I commence with

A. Cawnpoor Line

From

From Nanoon to the Dubowli
Cliff which lies at the head of
the Campoor Terminal works,
and to which point the Bridges
to be here described are limited;
the distance is 165 Miles; the
rectangular Section of the Canal
Channel varies from a maximum
of 80 to a minimum of 20 feet
in width. The design for water
ways upon which the Bridges
were commenced was as follows:

From 1st	to 30th Mile	- 3	Bays of	33	feet each
" 30th	" 50th	do	3	do	30 do
" 50th	" 70	do	3	do	26 do
" 70th	" 85th	do	2	do	33 do
" 85th	" 120th	do	2	do	30 do
" 120th	" 140th	do	2	do	25th do
" 140th	" 150th	do	1	do	30 do
" 150th	" 165th	do	1	do	25 do

giving an equal Series of dimensions
so that the native Mistries might
after building one Bridge be at
no loss in completing the others.
I have elsewhere described the cause
~~of the necessity~~ which led to an
alteration in the above arrangement,
and which forced us, even at the
expense of additional labor to the
Superintendent to enter into a more
minute graduation of the water
ways, thereby reducing the Cubic
Content of each work, and the
quantity of Material. The dimen-
-sions of the waterways on the re-
-vised Plan have been shewn in
the 2nd Part, when describing the
progressive development of the
Project.

Although differing in
width of Span of arch, the Bridges
are all on one design with the
exception of ~~[illegible]~~
3 of the Single arched Bridges on
the

"964

the upstream side of Dubowli, a description of which will be given presently. They consist of plain 60° segmental arches, supported on piers both with and without batter, the Cutwaters terminating at the Spring of the arches; these Cutwaters are finished by a cornice which encircles the pier, and from above which, the Spring of the Arch commences; the tops of the Cutwaters on the up and down Stream sides are crowned by an elliptically sloped dome. On each flank are towing path passages 4 feet in width. The wings of approach are on their concave or external side fitted with steps for the convenience of access to the berm levels. In all other respects the face of the Bridge is quite plain topped by a cornice and parapet of as few points as possible, and in every case the roadway, and consequently the lining out of the courses is perfectly horizontal.

In cases where Rajbuhas and Inlets are attached to the bridge, the design is precisely the same as that explained in the 2nd Section. The Ramps of approach are on a slope of 1 in 50, excepting at the crossing of the Grand Trunk Road and its branches, at which points this has been reduced to 1 in 100. In ~~all~~ minor details one general design has been pursued in all these works: differences in the parapets and cornices being the only deviations from a strict uniformity.

The soil throughout the Cawnpoor Terminal line is good for foundations, in very few places have we come in contact with sand

sand, and generally speaking the virgin earth is as hard and compact as it could well be. Beds of Kunkur in block or in tabular masses have (strange to say from its abundance in the neighborhood) seldom been met with, but in the form of loose gravel it is universally found either in beds or scattered indiscriminately through the soil.— Superficial efflorescences of Soda are characteristics of all this part of the country; the Alkali is as I have before said very injurious to brick making, and I may remark in passing, to Brick or Kunkur Structures which are raised in connection with it. The nature of the Earth in which the foundations have been laid, has led to great variety in their depths;- the curtain walls or those stretched across the Channel and forming the up and down stream sides of the Bridge foundations have in all cases been carried to the Standard depth: the cross walls or those on which the piers and abutments rest have frequently when the soil was good been omitted, the superstructure being raised on a massive flooring, extending over the whole surface from the back of one abutment to that of the other, and in frequent cases between the 100th and 165th miles the Counterforts in rear of the abutment walls, or the supports upon which the Towing Path passages rest elsewhere, have been ~~also~~ omitted.- For plans and sections of these foundations see Plate LIII of the Atlas.—

The Material used has depended entirely upon the re-

=sources

=sources of the Officer engaged in any particular part of the line, in some cases Kunkur has been the sole material, in others brick; whereas it has been by no means uncommon to use both brick and Kunkur in combination. At the villages of Busseypur, + Bahosi, Gonaha, Oomurda and Duggutpoor, the Arches of the + Briages are built of Kunkur, which at this point is of a very superior quality, free from the honeycombed texture which is the characteristic of the Kunkur formation, and quite as compact as many of the newer Limestones - As a general rule however, the arches the largest of which has a Span of 35 feet ~~only~~ are built of brick. The Cement consists + principally of

3/5 ths Kunkur Lime
2/5 ths Sookee or Bujree

the detail of which, together with the Amount of material &c will be found in the Table in appendix J

The average rates have been as follows:-

Arch Masonry	pr 100 Cft	21	8	6
Plain do	do	14	7	9
Plastering	pr 100 Sft	3	1	9

and the average Cost per Briage may be estimated at

Arches	each	33 feet	Span	11025	13 2
do	"	32 feet	do	10935	1 5
do	"	31 "	do	10081	8 ..
do	"	30	do	10050	5 7
do	"	29	do	9932	15 4
"	"	28	do	9891	12 11
do	"	26	do	9859	15 ..
"	10	35	do	9574	7 5
"	"	33	do	9656	13 5
"	"	32	do	9583	5 1
"	"	30	do	8747	12 4
"	"	25	do	7721	.. ..

The Bridge on the High road between Mynpoor and Agra designated the "Dunahar "bridge" consists of Segmental Arches of Span each; and differs from those of No 5 Class in having rusticated Pilasters which stand upon the Cutwaters of the Piers, and flank the tow-
=ing

-ing plate passages, With the
exception of these trifling de-
-viations from the Standard
Plan the Bridge corresponds in
all material points with the
others - It is built with Kunkar
and brick mixed, and, the width of roadway & the
proportions laid down for Bridges
over High Military Roads.

The old road, between Mynpoorie & Agra
crossed the Canal at an angle of 65 degrees,
its alignement was very irregu
-lar, and although Metalled
and raised sufficiently above
the country, was open to much
improvement. - I had in all cases
avoided skew bridges, in consequence
of the great additional expense that
they would lead to, as well as that
the only legitimate excuse for de-
-parting from the rectangle is
where the crossing occurs in the
midst of Towns, or land of a very
valuable description which would
be injured by an attenation of
approach; or, in cases where the
facilities of thoroughfare would
be materially benefitted; as neither
of these desiderata existed at the
crossing above alluded to, the
Dunahar bridge has been con-
-structed at right angles to the
axis of the Canal, and the ap-
-proaches have been brought to
bear upon it in sweeps, as shewn
in the Plan of this particular work
the whole of the approaches have
been laid out with great care
under the eye of the Executive
Engineer, and I do not anticipate
any objections to the omission of
the Skew. -

The average rates per 100
Cubic feet at the Dunahar
Bridge

Bridge are:-

Plain Masonry	15	4½	pr 100 Cubic ft
Arch Do	21	[illegible]	pr do
Plaster	2	10	pr 100 Sft

and the Total cost of the work is Co Rs 12,19..1..4½

On reaching the 12.5 Mile, the bridges are reduced to a waterway of 30 feet in one Segmental arch.. Of this description of Bridge there are 8 (25)

Those at Koorsooli, Bana, and Muswanpoor having — Pilasters between the Towing Path passages ~~[illegible]~~ and the main arch. ~~[illegible]~~, they are in design and construction simi=lar to those before described. At the village of Khujoori where the Canal is crossed by the high road between Canonpoor and Kalpi the bridge which is on the last di=mension above noted, is built on a Skew with an angle of 37 degrees: the road on its approach to the Canal was well lined out, straight metalled, and of uniform dimension, the angle of intersection was at the same time moderate; here, therefore, was a case where the Skew pattern might be ~~very~~ appr=opriately introduced, and it has been completed very satisfac=torily, leaving the original alignè=ment in its former State. The Bridge both up and down stream is protected by Ghats with Steps of descent from the higher levels of the roadway. The ramps of approach are on a slope of 1 in 100 and the finishings both in Masonry and earthwork are of the same description as elsewhere.-

These Bridges are built entirely of brick with Cement consisting of

2 parts of Kunkur Lime
1 - of Soorkee or Bajree

The average rate per 100 cubic feet of Masonry may be estimated at.

for Arch work Cos Rs 19.. 12. 3 per 100 Cubfeet
" Plain " 13. 12. 6 per "
" Plastering 3 .. 4. 6 per 100 Sft

The Cost of each of the plain single arched bridges was on an average equal to Rs 684 4. 12. 4 - that of the Skewed Bridge at Khujoori was Cos Rs 9 34 1 .. 10 .. 6

On the Cawnpoor Terminal line from the head at Narowr to the Dubowli Escape, which as I have before said is 165 Miles in length, there are 57 points at which the Canal can be crossed by the Public, the average distance between each bridge being 2·89 Miles This with a proper adjustment of roads (the positions of the bridges having been determined with reference to straight lines drawn between the leading Towns in the Districts) and especially by the radiation of village tracks towards the main roads of approach, ought to throw the whole country open, and render the means of cross communication sufficient for all practical purposes.-

B. Etawah Line

From the Narowr Regulators to the Moosanuggur Escape ~~are Bridges~~, between which the Bridges in this section are limited the distance is 170 Miles - The Channel is very similar in capacity and the design for the Bridges varies in no great degree from that which was laid down on the Cawnpoor Line. - Here, however,

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however, the resources of the Country have enabled us to maintain our Bridges on the original scale, and to construct them with the fullest liberality of Material. At the period that I am writing I may however observe that the works have not been advanced further than the 110th Mile, and therefore, that the Districts parallel to those in which the Executive Engineer of the Cawnpoor Line had so much difficulty in procuring Laborers and Materials have not yet been reached. Lieut Whiting, the Executive Engineer of the works does not, however, anticipate the difficulties or want of resources met with ~~by the Cawnpoor Tumnidar Line~~ and there is little probability, therefore, of our being prevented from completing the bridges as they were originally designed. These Bridges are as follows:-

From 1st	to	10th	Mile.	3	bays of	33 feet each
" 10th	"	30th	do	3	do	30 do
" 30th	"	50th	do	3	do	216 do
" 50th	"	70th	do	2	do	33 do
" 70th	"	90th	do	2	do	30 do
" 90th	"	110th	do	2	do	216 do
" 110th	"	130th	do	1	do	33 do
" 130th	"	150th	do	1	do	30 do
" 150th	"	175th	do	1	do	216 do

The design of the whole corresponding with that under the 5th Class with the exception of the single arched pilastered bridges which lie on the upstream side of the Moosanuggur Escape.-

The detail of all these bridges noting the Extent of Ghats and approaches to each, has been before given in the 2nd part of this paper

papers, and the rates and detail of material used, will be found in the Table in appendix, ~~It may be sufficient to state that~~ The average rate per 100 Cubic feet of Brick Masonry may be estimated at Rs 12.5.9 and that of Kunkur at Rs 11.12.0 and the average cost of Bridges as follows:-

3 Arches of 33 feet each	10892	9	8
3 " of 30 "	10121	4	4
3 " of 26 "	9143	6	9

The nature of the soil on the Country through which the Etawah line runs, is very similar to that which I have described in the former sections; it has all the advantages of tenacity and retentiveness, and all its evils of local admixture with Soda. As a rule however, it is well adapted for foundations, and for the sustaining of abutments or retaining walls, when such walls are placed in contact with the virgin soil. The material both in brick and lime, and the method of using both either mixed or separately, are common to both the Etawah and Cawnpoor Lines; and as the standard rules for construction are the same in both, there appears to be no necessity for repeating what has been already said in a former section.-

We have within the limits of our present detail a number of bridges equal to 40 scattered over a line of 110 Miles in length giving between each Bridge an average

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an average distance of 2.75 Miles.
The same remark which I made on the subject of Roads applies here as it did elsewhere, the only way that the bridges can be turned to proper account, is by opening lines of approach to them, the funds for doing this are in the hands of the Civil authorities, and of the local road committees, each or both of whom will receive the most ready aid from the Canal authorities, if they please to take advantage of it. — At the time that I am now writing, considerable progress has been made in lining out and construc-ting roads connecting the bridges on the Etawah & Cawnpore Terminal lines, most of which have been completed between the Ranoon Head & the High road between Agra and Mynpoori. I am greatly indebted to the exertions of Lieut. Whiting of the Engineers the Executive Engineer of the Etawah Terminal line for the great progress that has been made in road making in the Districts connected with his works.

V. Bridges on the Branches

This section includes the Bridges on the Futtigunj, Bolundshuhur and Koel Branches, works which from causes before explained have, up to the period at which I am now writing, been only partially proceeded with. With the exception in fact of initiatory surveys, the completion of the leading 6 miles of the Bolundshuhur Branch, arrangements for material in the early part of the Futtigunj and Bolundshuhur Branches and the completion of the works at the Heads; nothing has been done. In the design of the Bridges, however, I have no idea of deviating from that which has been put in practice on the main Trunk line; the plan of combining with the bridges the different works for Inlet and Outlet appears to have great advantages, in both compactness of design and convenience of supervision; it gives good drainage to the Bridges in the neighborhood of the approaches which must necessarily be much elevated, and the flat Segmental arches, by admitting of increased rise to the height of the piers, gives facilities to the transit of boats and rafts, whilst they secure to the roadway the smallest possible rise above the level of the country.

~~The necessity of a passage for boats, as the foundation and foundation of the Bridges must be~~

The width and capacity generally of the Rajbuha Heads might be retained at the minimum measurement, used on the main Trunk line, viz: with a width of 6 feet; that of the inlets I would

retain

retain on the standard measure-
=ment, which gives space for the in-
=troduction of laborers for the pur-
=pose of clearance. The length
of Ghats or face for giving protection
to the Head of the Rajbaha, and
the retaining wall in its rear,
might be very much reduced,
the former to a mere platform
sufficient for working purposes
the latter altogether, Steps of des-
=cent being constructed (as has
usually been done elsewhere) on
the concave surface of the wing
walls. Unless experience points
out that the position of the Raj-
=baha head and Channel thus de-
=signed is inconvenient, and
liable to interruption from silt
and Sand deposits, the modified
design for the Branch Bridges as
above suggested will I think be
a good one, and at the same
time moderate in cost.

Under the above explanation
and in the order of precedence in
which the branches are situated
on the main works, I would for the
Suttuguh Branch adopt the
following design for waterways

	Width of Cs. Canal in Rec: Channel	Bridge Waterway	Bays Divided
From 1st to the 15th mile	70 feet	75	3 Bays of 25 feet
39th do	65/60½ feet	60	3 " of 20 "
69th do	55/50½ feet	50	2 " of 25 "
108th do	45/40½ feet	40	2 " of 20 "
132 do	35/30½ feet	30	2 " of 15 "
150 "	25/20½ feet	25	1 do of 25
159th "	"	20	1 " of 20 "

On the Bolundshuhur
and Koel Lines where the width
at the Head is 50 feet, the table
above given would be equally
applicable.—

For

For the Elevations, Class 5 would be that appropriate to all the bridges with more than one arch - The single arched bridges might be similar to those in the vicinity of the Terminal works on the Cawnpoor line - that is to say with the Towing path passage flanked by Pilasters; or, what would be more economical, and perhaps more appropriate to village and Country bridges, they might be made perfectly plain like those in Class No 5 above noted

It is unnecessary to say anything further on the construction of the above works, as they are copies of those which have been already built, of which plans and all necessary sections are thereon in the attas. -

This Chapter would be incomplete were I not to add some concluding remarks on the Bridges which have been described in the preceding pages and which have been completed previously to my resigning the Directorship of the works. These remarks will naturally apply to the classes separately, an arrangement that will enable me to bring under review the different works under their exact Specification - Commencing therefore with.

No 1. Class

The standard design of which is figured in Plate XLIX of the Atlas

The Bridges under this class are as follows; including those which are attached to the Solani

Solani Aqueduct Termini.

1 Kunkhul
2 Sowalaproor
3 Mukewar or Upstream Solani Aqueduct Termini
4 Pookee or Down Stream Do
5 Gunesproor (Substructure only)
6 Munglown
7 Sibuglieu
8 Mundowli (substructure only)
9 Dinat
10 Joghulproor
11 Belra
12 Bhopra
13 Khutowli.

The Mundowli & Gunesproor works are as I have above explained left in an incomplete state, so that they may hereafter be finished with masonry arches, [illegible].

The five leading Bridges on the list were built under the Executive Superintendence of Captain Goodwyn of the Engineers, the remainder by Lieut. Fraser of the same corps, aided by their Assistants [illegible].

The Arch although with an elliptical outline on its intrados is, as will be seen by the plan, a segment, the voussoirs being brought to bear on one centre, the impost blocks or skew backs on which it rests, are formed by horizontal brick work, which is projected so as to form the lower portion of the elliptical curve. In one instance only, viz: at the Munglown Bridge this rule was experimentally departed from, the voussoir in that case being brought to bear upon

5 centres and the arch being constructed on an Ellipse. ~~The 10th~~

The thickness ~~of the 11th~~ Chord of Arch was 3 feet, in all ~~Bridges~~ cases it is 3 ft. ~~The remaining~~ ~~Bridges are built of Brick and~~ ~~Brick or Kunker~~ ~~on centerings, except~~ ~~the arches of the Brick~~ ~~are built~~

On my rejoining the works early in 1848, the Piers and abutments of the Kunkhal, Dowalapoor, Munglour and Sibrulhee bridges were completed; timber centerings had been prepared for the Arches, and the works in question were in progress of induration. The brick Manufactories which had been since the year 1842 in progress, under interruptions of various kinds, had at this period arrived at a fair state of organization, and from the Head Works to the Town of Sirdhanna, not only had large supplies been collected, but Kilns were in progress in sufficient numbers to secure an energetic advancement to the masonry works. The whole of the bridges therefore, which are included in the present class, were completed without delay.

With the exception of the 2 Bridges which are attached to the Aqueduct, and to the works in the immediate vicinity of Roorkee, none of these bridges have escaped without settlement after the superstructure was built, this was shewn by slight openings on the parapets over the haunches of the arch, generally speaking not extending below the cornice and in all cases even in those of the Munglour and Dowalapoor Bridges

with the exception of the arches the Khatowlee bridge which were turned on centerings made with plain cut the arches of the above Bridges built on Timber ribs resting on Cross walls of brick with mud cement

I must look to these heads again before recorded.

Bridges where they have appeared most prominently, of very small dimensions. The whole of these Bridges with the exception of those at the Aqueduct and at Khutowli appear to me to have been some-what hastily executed, the outer coating of this material having been laid on before the arch had permanently settled, and before the masonry had become perfectly indurated, ~~[illegible]~~

Having drawn attention to the Jowalapoor and Mungloor Bridges, I may observe that the defect in the former may be derived from an accident which occurred to the right abutment and wing shortly after the work was finished. During the rains of 1830, flood water broke into the Canal from the ch bank near the right down stream wing, which it carried away. It is possible that what with the shock of this accident and what with the torrent of water pouring into the Canal at the back of the right abutment, this part of the work suffered. The defects to which I have alluded are merely an extension of the openings to which I have before alluded as not in any way touching the arch itself, and which in the present case have been very well repaired. In relieving the arches from the centerings the settlement was considerable, as will be seen on reference to Table I of the appendix.

The

The Mungloon Bridge is the only one in which the voussoirs of the arches are directed upon numerous centres, and whether from this cause or otherwise, the settlement has been more here than elsewhere. The lowering of the centerings of this Bridge which was the first constructed in the 2nd Division of the works, was superintended by Mr Read in person, the result in the case of one of the arches was unsatisfactory; the actual sinking of the crowns on the removal of the centerings was thus-

Right arch	3·78"
Centre do	3·77"
Left do	4·52"

The two former stood the ordeal well, but on the left for a space of 5 or 6 feet across the arch on the upstream side, cracks shewed themselves, of sufficient opening to admit of a flat ruler being pushed in to the depth of 6 or 7 inches, the bricks at the crown and haunches of the upstream face appeared too to have been somewhat disarranged. Both the keying and bricklaying of these arches were carefully looked after, but the Executive Engineer supposed that some careless brick work had been introduced, and that in defiance of all supervision, the construction of arches of large dimensions with the inexperienced workmen with whom we had to deal, would be liable to annoyances of this sort. This Bridge was allowed to stand without Stucco for 24 Months, on the completion of which time, it was concluded that

that any further settlement was out of the question. Since the completion of the stucco, slight openings have appeared in the parapet walls over the haunches, and although there is no reason to apprehend any serious extension to these openings they ~~are~~ disfigure the appearance of the work, but are otherwise of no material importance.

I have in the leading Section of this Chapter when treating of Centerings, explained the universal separation that took place on the flanks generally speaking from the 6th to the 12th course from the skew back; with Timber centerings the 60° arch that we have used, has in every case exhibited this peculiar feature. — In the Earthen Centerings, the causes that I have shewn for the separation at this particular part of the arch, are more clearly recognizable than those in the case of the Timber Centerings. In the former the separation distinctly takes place during the building, and when the weight of the arch begins to act upon the compressible material of which the centering is composed: in the latter ~~the~~ the separation occurs until the arch ~~is~~ was keyed and the centering ~~is~~ removed. — In Table I which will be found in appendix, the amount of settlement on the removal of the centerings is shewn of each arch that has been constructed. — The action on the haunches and the amount of settlement are clearly due to the nature of the seams of mortar in voussoir, the necessity of attending to which in its greatest minuteness is a matter of very serious importance

For instance, the length of a segment of a circle of 60° whose radius is 33 feet, is 34·55 feet; in examining this arch I find that the number of courses of 3 inch Bricks which have been laid in voussoir ~~is~~ equal to 126. That 126 × 3 = 378 Inches or 31½ feet, and that consequently 3½ feet in length of this arch consists entirely of a soft compressible material. Now, on 127 Seams the average width of each on the above results is ·285 Inches. whereas the width of seam with mortar as it is commonly ground ought not to exceed ·25 of an inch (properly speaking and with well cut bricks ·175 might be obtained) —

All excess over the minimum dimension abo~~ve~~ve noted may be considered as directly tending to Settlement more or less injurious to the Arch. ~~Two~~, In a case that came under my notice in which the Argument held was that it was better to allow the native Misteri to follow his own habits, which were founded on Experience of the value of the material with which he was working, than to interrupt his progress by the introduction of European systems: a series of arches had been built with excellent 3 Inch bricks, and with ~~good~~ Kunkur lime Cement the latter somewhat coarse, but ~~known~~ supposed to be of a good quality for Hydraulic purposes. Some of these arches were Semi-circular, others were flat Segments similar to that described above; the Seams of Cement were in no solitary instance under 3/4 of an Inch thick, generally Speaking they

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they were above an Inch, and they were ~~averaged~~ averaged in my note book as 1 Inch Seams. The number of 3 Inch Bricks in an arch of the above dimensions is 100 giving a total length of 25 feet. of the full arc, therefore, there were in this case no less than 9:55 feet in length of mortar. that is to say of a matter purely compressible, and directly detrimental to the stability of the arch. I may observe (and this is a fact that was not considered ~~in the~~ by the builder ~~illustration above given~~) that the native Misteri never removes his centering until the material of which his arch is composed is perfectly indurated; he never, moreover, dreams of building flat segments, his form of arch being confined to pointed of varieties and to the Tudor outline; The segment (which is ~~a a b c c a~~ entirely copied from the English), is ~~a d e~~ with the native Misteri semicircular, built of the most massive proportions, upon which its strength depends more than upon its correctness of poussoir, or from the equilibrium of its parts. The adaptation, therefore of the native Style of building without due consideration is altogether inappropriate; and the proof of its being so, was shewn in a case where the arch of a towing path passage which had been built on the native plan with seams (as after examination shewed) of upwards of 1 Inch in thickness, was in the course of a few months utterly destroyed, by the passing of carts over it, and by the vibration attending thereupon ~~from~~

therefrom upon, completely disintegrating the mortar; the bricks actually separated and dropped out, leaving holes through the crown of the arch. I am aware that with roughly formed bricks it is difficult to obtain seams of the reduced thickness, but it is economy in the end to cut such bricks into shape. I prefer this at any cost, to concentric rings which is one way of getting out of the difficulty, and which in fact was adopted in the Works at Mysoor; but if ~~I do not suppose~~ it as an accepted fact, that no two arches settle equally or uniformly; it follows that if 3 lines of arches are laid above each other, and are built with the intention of performing the duties of a solid arch; ~~that~~ any inequality of settlement of the 3 concentric layers will defeat the object in view; nor will an occasional bond formed by bricks dovetailed between the rings which I have had pointed out to me on English Railway works, as an antidote to the evil of which I complain, act further than in disarranging the equilibrium which really does exist without them. That a reduction in the extent of seams is gained by the concentric layer system, I admit, but its liability to irregular settlement appears to me to ~~exceed~~ under its advantages questionable ~~its advantages considerable~~.

On the Ganges Canal works the greatest attention has been given to the reduction to a minimum of the seams both in plain building, as well as Arch work, and I would bring forward the whole of the Works on

on the Solani Aqueduct, as well as those in the Khadir as good Specimens of close and, according to my idea, well laid brick work. On the whole line of works in fact from Myapoor to the Termini, there are few arches that I would not produce as illustrations of excellent brick ~~work~~ laying. The ~~whole of the~~ bridges under this class are built entirely with brick.-

No 2 - Class

The Standard of which is figured in Plate L of the Atlas. -

These Bridges which are very similar to those above described, and principally differ in their having a segmental instead of an Elliptical intrado, are built in one continued series from the 106½ to the 180th Mile; they consist of 2 varieties of waterway, the leading ones having 3 bays of 45 feet each and those which are situated below having 3 bays of 40 feet each.-

The works under this class may be thus enumerated-

3 Bays of 45 feet each.-

1	~~Baoli~~ Pupulkera	8	Dhumkoora
2	~~Pupulkera~~ Raoli	9	Urrowli
3	Nidhowli	10	Wubbipoora
4	Sarcha	11	Mamun
5	Geesoopoor	12	Uchuhja
6	Sumowta	13	Moondakhera
7	Pukkanna	14	Subenda

3 Bays of 40 feet each

1	Daopoor	5	Barota
2	Birowli	6	Machoora
3	Dubtekla	7	Chungeri
4	Kasimpoor	8	Sheka

making a total of 22 Bridges.

The two leading Bridges at Ravli and Pietrathera were built under the Supervision of Mr Read the Executive Officer of the 2nd Division. The whole of the others were laid out and comple-ted by Mr Volk the Executive Officer of the 3rd Division of the works. The design is similar to that originally proposed, with modifications adapted to the Project of 1850.- The introduction of Block Kunkur in conjunction with brick is the most remark-able feature in this class of bridges. - Block kunkur in fact may be considered the staple material for the whole of the building with the exception of the arches, which are invariably made of brick, brick too is used generally speaking in cornices and finishings, but not uni-versally. —

The arches of the Ravli and Pietrathera bridges were built on plain kutcha centerings similar to those which under the Section on Centerings I have placed under the denomination of Class II A. Those from Nidhowli downwards were built on centerings composed of external ribs of temporary brick work with an interior filled with earth, as shewn under the head of Class II B. I have in its proper place given my opinion as to the value of these different sorts of centerings, it is only ne-cessary to state, therefore, that they have with the exception of the two cases above mentioned been universally adopted in the build-ing

=ing of the Bridges of the 2nd Class.

From the nature of the Centerings and the rigidity of the external ribs, which prevented the settlement which I have before alluded to, the separation at the haunches as shewn so distinctly during the progress of the building of the Arch, was less frequent here than in the cases above described; it was seldom observable until the Centerings were entirely removed, and then in a very slight degree: as a rule, however, after the construction of the parapets, and when the arches were loaded to their fullest extent, exceedingly slight openings exhibited themselves in the parapets over that part of the haunches to which I have before alluded; the settlement merely shewed that the same action, and the same cause for it existed in these bridges as it did in others,

The use of Block Kunkur so largely throughout these works and its satisfactory appearance when the Bridges were completed rendered it a matter of regret that they should be stuccoed. In

Cases

cases where mixed material had
been used, such a coating was
desirable, but in others as far as
mere appearance was concerned
the plain stone buildings would
have been a pleasing variety. The
texture of Kunkun, is honeycombed
and as a rule not compact, In
extremes the stone may be described
in its most perfect state, as a grey
semi crystaline rock, tough, with
occasional amygdaloidal, or irregularly
shaped hollows dispersed through
-out its mass, the hollows being
filled with earth, In its most
imperfect state (I allude simply
to the Block Kunkun which is
available for building purposes)
these hollows are more numerous,
and they give to the rock the
honeycombed appearance to
which I have before adverted. It
is found in extensive Tubular
masses or Strata (generally ac-
-companied by Sand) the up-
-per and lower sides of which
are Slaty and apparently im-
-perfectly indurated, the indura-
-tion in fact increases towards
the Centre, where it is frequently
of the hardest description of
the newest Lime rocks, and
of a crystalline character. In
using this material there were
a few indispensable rules to be
attended to

1st The entire removal of the outside or Slaty portion

2nds The placing of the masses in a horizontal position, and in courses corresponding with their laminæ, or with that in which they ~~lay~~ lay in the Quarry -

3rd

Alder

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3rd In using the material at all, the greatest attention to be given by the Engineer superintending the works not only to the efficient quality of the material, but to seeing that the two former rules were abided by.

The outside was hewn off by the Quarry laborers in some cases, in others at the works themselves. The heavy axes (Koolharies) were used for this purpose, and as far as my periodical inspection admit of judging, the 1st Rule has been strictly attended to; the chips or fragments removed from the blocks in preparing them for the building, have been used as metalling on the Roadways. As far as such was possible, the 2nd Rule was followed, and there is no doubt that the strictest attention was given by the Engineers to the Quality.

After all, however, good as the appearance was of works built with Kunkur, it was very evident to me that from the nature of the material, and from its honeycombed texture, its outside surface required protection from the action of running water, as well as from that of weathering. In the former case it was clear that stucco must be used, as the current would in a very short time relieve the hollows from their earthy particles, giving the outside exposed to the action of water a most unsatisfactory if not dangerous surface. In the latter case where the work was not exposed to the attrition of water, the very nature of the rock calcarious

calcareous and rusticated in
surface, laid it particularly open
to the effects of weathering, to the
reception of seeds and vegetation
of all descriptions to which build-
-ings in India are subjected, and
to both these evils being consider-
-ably magnified by the excess
of moisture that will attend
upon the introduction of irrigation.

I may observe that although
I had no experience of the effects
of attrition of current upon this
species of rock, its use in buildings
is so common in these provinces
that there can be no mistake about
its efficiency in the first place, and
the action that weathering exerts
upon it in the second; the latter
is in direct proportion to the
extent of the honey combed nature
of the stone used; where this is in
excess the surface assumes an ap-
-pearance like that given to rus-
-ticated pillars and plinths, where
loose bits of gravel have been
stuck in mortar. where the rock
is compact and crystalline it
withstands the weather as well
and better than our Freestones and
Oolites of England; in this case it
is an admirable building stone;
Its color is grey and therefore cold,
which in a hot climate and under
a boiling sun may be considered
rather advantageous than otherwise

In extensive works like those
with which we were connected, it
was impossible to draw very
minute distinctions, and in fact
the very superior class of Kunkur
which I have above described is so
rare, that it never existed uniform-
-ly in any particular work it was there-
-fore determined that the whole

of

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of the bridges whether built of kun=
=kur or not should be stuccoed,
and that experimentally the back
retaining walls connected with
the Embankments, which were out
of the reach of the Canal Channel
should ~~ought~~ be left unplastered, so that
hereafter an opinion might be
formed as to the advisability or
not of leaving kunkur surfaces
exposed. All these kunkur works
therefore as far as they are directly
in contact with the water in the
Canal Channel are stuccoed,* and
I confess that there was a roughness
and irregularity of courses about
the kunkur, that lead me to look
upon the change with no great
regret. —

Note

* Since this was written many of these bridges have been entirely coved with Stucco

No 3. Class

The Standard of which is figured in Plate LI of the Atlas.

The Bridges under this class are five in number, they commence immediately below the Head of the Tattigurh Branch, at the 54th Mile, and with the ex=
=ception of the Khutowli Bridge continue uninterruptedly to the 72nd they are called

1 Dukheri Bridge
2 Jansut do
3 Turai do
4 Sutheri do
5 Utterna do

I have before described the cause in which the designs of these Bridges originated. They are built exclusively of small native bricks which were procured from the ex=
=tensive ruins at Bhitowra and other places in the neighborhood. To meet the insufficiency of this

this species of material for 60° segments, the rise was increased to 10 feet, and to break the continuity of the surface given to the spandrils by this excess in the rise, ~~the arches are to open~~; the bridge roadway ~~is~~ has been supported on an open line of Arches resting upon the segments as open ribs spanning the waterways: by this arangement the superstructure was reduced both in weight and extent - The sides were flanked by towing path passages. -

These Arches were built on plain earth centerings, and from the nature of the brick that was used, and the consequent superabundance of Cement which it necessitated, the settlement on the removal of the centerings was considerable. Three of these Bridges were Stuccoed very shortly after the Masonry was completed, and subsequent settlement has produced the same disfigurements in the parapet walls as I have ~~mentioned~~ as existing in those before described ~~as~~, the plastering of which was somewhat injudiciously hurried forward. The defect is more conspicuously marked on these bridges from its appearance on the Arches which occupy the spandrils. In portions of these works connected with the wings of approach, and the steps of descent which are attached to them, it was found necessary to substitute the large for the small brick: proximity of Kilns to the Dukheri and Sansut bridges especially rendering such an arangement a matter of no difficulty. - I have not been at

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at all satisfied with the results of building with the old bricks. From their small size, and frequently being in fragments, the proportion of cement is extraordinarily great, so that the building in mass consists of mortar in a proportion that exceeds all belief. A specimen of a wall which fell during the rains of 1852, presented a most unusual exhibition of this material. In addition to this, in itself a great defect, the ruins which were composed of Bricks laid in mud, although easily pulled down from the circumstance of the facility with which the bricks were separated, produced a material more or less covered with dirt, and with all the care that was given by the Executive Officer, no washing could utterly get rid of it. An earthy substance in contact with the brick was destructive to the proper adhesion of the lime cement and was in itself, therefore injurious. These two defects although ~~tabulating~~ against the value of the masonry, and in comparison with that made of the new and larger sized bricks shewing that that built with the old, is inferior to that built with the new, are merely pointed out as the results of our experience on these works. ~~[illegible]~~ The Lime that has been used is derived from a very superior description

operating from the value of the masonry shewing that when constructed with old bricks it is decidedly inferior that composed of the new and ger sized kind,

description of Marle (called Earth Lime to distinguish it from that burnt from Kunkur); the Bricks with which the ~~arches~~ were built arches were I believe very carefully selected, washed and laid, and as far as quality is concerned are of the very first description, as all the little bricks used by the Natives are.— In both these respects therefore, viz:. in goodness of Lime and quality of Brick, nothing could be better than the material with which these bridges are built, but their good qualities are neutralized in part ~~thereby~~ by want of bond, excess of Mortar, and introduction of foreign matter in the shape of mud into the Masonry.—

On this subject I may remark, that the presence of the ruins which provided the works with such an enormous quantity of material has been the main cause of our being able to complete such extensive works in so short a period of time. By singular good fortune, the Engineer might perhaps say, by a providential arrangement, these ruins were in the market, on the only part of this District where good brick soil was scarce, and where fuel was (at a reasonable cost) literally not procurable; he found himself in the midst of plenty when on the brink of starvation, and neither he nor I can be much blamed for feeding on manna in the wilderness, although such manna, might not have been equal to the things on the rich man's table.—

No: 4, CLASS

The Standard of which is figured in

in Plate LII of the Atlas

The Bridges under this class, commence at the 77th mile from that below Sirdhanna to the Noorpoor Bridge or that situated at the 103rd mile, they come under the following designation

1	Nanoon	6	Newari
2	Suttpoora	7	Soonda
3	Pooth	8	Didowli
4	Jamikhoord	9	Moradnuggur
5	Nugla	10	Noorpoor

The buildings have towing path passages flanked by rusticated pilasters, with the Spandrils pierced by cylindrical holes; in other respects they are quite plain.- The settlement of the arches which are segments of 60°, and which were constructed on plain earthen centerings was less here than elsewhere I believe that the experience gained in building former bridges was partly the cause of this result, and at any rate the delay in completing the superstructure, as well as that of covering the exterior with stucco has been successful in diminishing the disfigurements to which I have before alluded.- In these bridges, however, previously to the building of the parapet walls, [illegible] The separation at this point was exceedingly small but I draw attention to it, as a proof that settlement at this period of the progress of the building was

I have no doubt

settlement of the haunches
wed itself in the crown of the
andrils cylinders; the action
ring ceased itself in these cases
me separation, centrically
ated between the two haunches.

was here as elsewhere prevalent.
~~[illegible]~~. The whole of these works are built of new brick, and they appear to me to be the best constructed bridges in this part of the Canal. The brick laying in the Arches was particularly good, and the seams were reduced to a minimum. The Span of each arch is 50 feet in width, and the depths or thickness is 2½ feet at the Crown and 3 feet at the impost Blocks.

No 5 CLASS

The standard of which is figured in Plate LIII of the Atlas.

An enumeration of the Bridges in this class will be found in the 2nd part of this paper, under the description of the Cawnpoor and Etawah Terminal lines to which they are entirely confined. — They are quite plain with no other ornament than a cornice round the pier and cut water heads, and a string course separating the parapet from the face of the building. With two exceptions in the Cawnpoor Line where the Span of the bridges has been increased to 35 feet; the Maximum Span is 33, and the minimum is 25 feet. Kunkur and brick have been used indiscriminately as one or the other was available; the latter being with the exception of the Arches of the Kasseyrun, Balosi, Gonaha, Oomunda and Jugguttpoor

Bridges

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Bridges, universally applied to the construction of the Arches. The whole of the Arches of this Class were built on Centerings of Earth supported on each side by buck and mud walls on the plan noted as Class IIB. After the removal of the Centerings, the separation which I have before described, and which in fact has universally attended the removal of every Centering whether of Timber or otherwise, occurred I believe in all cases, and always in the same position, that is to say, at a distance of from 6 to 12 courses of brick from the impost block; further action appears to have depended greatly on the application of the Superstructure.

The instances where Arches were built of Block Kunkur, the Stone was of a very superior quality, and well adapted to any species of building. In texture it was compact and crystalline and with hardly any traces of the earthy concretions which are so characteristic of the Kunkur formation. Here, however, as elsewhere I have sacrificed the desire that I had for exhibiting this stone as a becoming one for ornamental building, to the fear that was entertained of the joints giving cover to vegetation, and of the surface being injured by the action of the current or disfigured by weathering. These Bridges have been coated with

Stucco

Stucco, in the same way as those which I have described under the head of Class No 2.

I have a few remarks to make on the Bridges, which as not conforming in Elevation and design to those legitimately answering to the Classes above mentioned, have been separated and placed by themselves. These as will be understood from what has been before written consist of the

1. Cross Bridge at the Rutmoo Works
2. Peeran Kulleeur Bridge
3. Sirdhanna Bridge.

and the Single arched Bridges lying above the Terminal Works which may be thus denominated

On the Cawnpoor Terminal Line
Koorsoulee
Bara
Muswanpoor

The cross Bridge at the Rutmoo is in Elevation similar in many respects to that of Class No 1. its arches are elliptical and described on the same number of centres, but its cutwaters are not surmounted by Pilasters. Circular headed niches, however, placed centrically over the Cut. waters, and dies sunk in the Spandrils, give it an appearance not

not unlike that of the class be-
=fore mentioned. The abutments
of this Bridge are more massive
than those of class No 1. They are
connected in their substructure
with the under drainage of the
Revetments. —

The Peeran Kulleem ~~Like those at the Pani~~
Bridge ~~Aqueduct, has escaped~~ the design
of which has been before described, was com-
pleted about the time that I left the works, at
this period it was without stucco; & altho' during
the construction of the arches settlement in the
usual form had occurred, the external face
of the Elevation exhibited no trace of it.

The Sirdhunna Bridge
which was one of the earliest
that was built, had its Super-
=structure laid on at a period
too shortly after the arch was
thrown to save the parapets from
the action of settlement; it was
stuccoed, moreover, immediately
after the building was finished.
The design differs from that of
No 1 Class merely by the introduc-
=tion of Flank Arching path
passages. —

On the Cawnpoor Line
the Bridges included in this
list were amongst the first that
were built, their completion and
stucco were hurried forward, and
the result is shewn in parapet
disfigurements. —

The haunches in every
case have been marked by a
separation in the voussoir, so
exceedingly slight as to be un-
=observable without close in-
=spection

=spection, but still existing in evidence of the action that has taken place. The defect does not appear to depend upon the sub=structure, but rather on a settle=ment of the crown of the arch itself. In all bridges without reference to extent of piers or abutments, or to the nature of the soil in which the foundations are laid, and especially where the superstructure over the arch has been hurried to completion, sub=sequent settlement has, although without any apparent increase to the defect above mentioned, shewn itself by an opening of the parapet walls; this also in a very slight degree, the fissure not being traceable in connection with the arch, but clearly I imagine depending upon it. I attribute the evil to the use of compressible centerings of the nature described in the leading section of this Chapter

I believe that in prac=tice where centerings are removed on the plan which I have des=cribed, and which is for the purpose of enabling the arch to acquire its proper equilibrium at a period when the Cement is moist, and when such moist=ure admits of the most perfect compressibility; the separation at the haunches is if not uni=versal, of such frequent occur=rence, as to render it a matter of no consideration; the openings in

in fact, become immediately closed, and the joints from the settle=ment of the Brickwork, and the softness or moisture of the Cement, attain a degree of fine=ness as also of uniformity, that could not be attained by any other means. It becomes a question, however, in how far such settlement may be due to the yielding of Abutments either by their turning on the base as a fulcrum; from the compressibility of the material of which the abutment is built; or finally, from the slipping of the horizontal courses of Masonry of which the abutments are composed.

Now with regard to the 1st point, or "the actual yield=ing of the abutment itself"; it will be seen by referring to my first rule for bridge build=ing that the intervention of Curtains and floorings to the bays, prevented the abutment from turning on its fulcrum or base line; where timber Cen=terings were used, these floorings and Curtains were universally built before the Arch was relieved from its Centerings; in other Cases they were absent. Whether however, they were present or absent the Separation at the haunch took place; the action, therefore, on the Arch appears to have been uninfluenced by this Circumstance. Again, in cases where

where the extent of the Abutment and its excellence of workmanship placed all probability of yielding out of the question, the separation at the haunches seemed to prove indubitably that the action arose simply from the settlement of the crown, and without reference to those parts of the structure on which the Arch rested. As I have taken much interest in the progress of these buildings, and have lost no opportunity of examining the impression that this action of Settlement exerts on the intrados of the Arch or on the work generally, by endeavouring to detect cracks or marks of separation on the one, or a want of perpendicularity or disarrangement in the other; these observations having been especially directed to those bridges where the Stucco had been finished, and the surface of which would necessarily exhibit the smallest possible defect,* I may remark that the cases where I have observed

* With the exception of the bridges which were built at the commencement of the works - viz^t. those at Kunkhul, Jowallapoor, Munglowr, Libunkeir, Jogulpoor, Dimak, Baiha and Bhopra to which either Ghats or flanks were subsequently added, the Bridge Arch abuts centrically upon a long line of wall which extends to a considerable distance both up and down stream on each side of the arch - The face of this wall is perfectly smooth and even, so that were the thrust of the arch to affect its abutment, action on the face of the wall would be inevitable, and could not escape detection. - In a settlement that took place in the Dhanveri Road Bridge, the settlement was marked by a separation of the wall on the upstream side, a short way

observed traces of action on parts of the building in the region of the Skew backs are exceedingly rare, and of a nature leading to great doubt as to their origin

In the instances of the Dukheri and Surai bridges + which come under the head of Class 3 where the building Ma-=terial is of Clu native Brick. the inside of the Towing path passages next to the Waterway shewed slight traces of action in an horizontal separation of the plaster at a point just + above or corresponding with the extrados of the Main arch and its impost block; the + separation was sufficiently dis-=tinct to attract my attention but the trace was exceedingly small and confined to the passage itself.. Evidence ap-=-prared to be offered here of the thrust of the arch having af-=-fected the Masonry.-

In a case of a single arched bridge of 30 feet span Class No 5, at the village of Barra similar horizontal separations took place in both the side + passages, extending more or less over the extrados of their arches; in this case the separations were more distinct than in those before described although they

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way above the point where the arch abut-=ted on it - In no other case amongst the numerous Bridges which have been built on these works, has this action been in the slightest degree shewn -

they were entirely confined to the region of the passages themselves, here, however, the soffit of the main arch shewed a hair line distinguishable on the stucco, distinctly continuous, but not traceable beyond the intrados. Evidence of action was here again manifest, and the trace on the soffit of the main arch, was in all probability dependant on the action exhibited on the side passages.—

In all these cases the defect may have arisen from the quality of the masonry. The very questionable nature of the cement used at the Barra bridge, and the unquestionable thickness of the seams, much acted on by [Salts], appeared to me to account for the separation described at the Barra Bridge

The nature of the soil in which the foundations of the 3 arched bridges at Dukheri and Surai were laid was sand; that at Barra was of an inferior description. No abutment sinking or disarrangement could have taken place from the reasons stated in the foregoing note; & and although it is possible that the centre piers of the 3 arched bridges may have settled, there is no evidence of such having taken place, nor do I think that such is probable.—

The actual vertical settlement

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(273 J. v. 2-p. 3. c. 3. Barnett)

=tlement however, of the sub =
=structure of the bridges extending
from Roorkee to the 110th Mile
is by no means an impossibility
It universally rests on Sand,
and in some cases, as it will be
observed by reference to the plans,
is embedded in the natural
Spring level Surface.. Traces of
such Settlement could not,
however, escape detection.-

With regard to the
2nd point, or "the compressibility
"of the Material of which the
"Abutments and Substructure
"are composed" in how far the
settlement of Arches may act
on the Skew backs it is not very
easy to discuss, but it is clear that com=
=pressibility in that region must
depend entirely on the nature
of the Masonry. Where this
is of brick compractly laid in,
with narrow seams and joints
of mortar, and allowed per=
=fectly to indurate, the Masonry
must be proof against any
force that Arches of our dimen=
=sions could exert upon it. On
the other hand, when the Masonry
consists of badly put together
brickwork, or of Kunkin either
of inferior quality or of uneven
=ly squared blocks, in which
cases the joints are necessarily
either large or imperfectly filled
with mortar, the compression
of the Material is by no means
an impossibility. If to the
above evils, a want of indurate

if

is added, the thrust exerted by an Arch would inevitably affect the Abutments. At one period of our Bridge building Kunkur was used in the imp= =post blocks, and the whole of thrust of the Arch was exerted on Masonry made of this ma= =terial; this was corrected after= =wards, and the best brick & Masonry was substituted for that of Kunkur; the use of the latter being confined to those parts of the work on which a dead vertical weight was exerted; the change was made from the possibility of Kunkur impost blocks being liable to compression from the Causes which I have before enumerated, but there is no evidence of their ever having acted injuriously, or of settlement to the arch having taken place from their use. —

If the Masonry whether of Kunkur or of Brick, of the Bridges above described, was laid in with all the care that it ought to, and which to the best of my belief it has been, in all occasions; compressibility although sufficiently active on the arch itself on the removal of the centerings, and up to the period of the induration of the Cement with which it is built, could not have extraor= =dinary influence on the rest the building. —

The 3rd and final
question

question to be considered is "the slipping of the Horizontal "courses of Masonry". In the Northern Division of the works where Stone lime and Sourkhi as a compound are used for the purposes of mortar; and even where the Earth Lime, which I have elsewhere referred to as of a very superior quality, has taken the place of Stone lime, the evil to which I am now addressing myself is one that can hardly be anticipated, certainly only in such cases where the thrust of the arch has been brought to bear on an imperfectly indurated mass, and such from the period to which the substructure has been invariably allowed to stand previously to the fixing of the Centerings, has not been the case with the knowledge of the Superviseing Establishment. In the Southern or lower Divi=sions the Lime is not equal in quality to that which is used above, and in some cases from the coarseness of the in=gredients which have been mixed with it, especially the Bujree or fine Kunkur gravel, the thickness of the Seams ex=poses the courses of brick or Kunkur to greater chances of slipping than would have been the case had the Mortar been of a fine consistency, or had the Seams been thinner. In a case of careless building

but

by a Contractor, we had an exhibition of this evil; but with this exception in which the arch fell as will be described hereafter, no bridge that has been built shews the Smallest sign of action from the slipping of the courses of the masonry.- I confess, however, that had I been prepared for the thickness of seam that has in some cases shewn itself from the use of course mortar, I should not have placed the Towing path passage in such close proximity to the waterway It is from this contingency alone, and not from any objection to the design otherwise, that I have throughout these pages recommended as a general rule, that the Towing path passage, and the waterway of the Bridge should be separated by a distance of 2 feet plus the width between the waterway and the point of intersection between a tangent to the extrados of the main arch and the flooring of the passage.-

In the construction of the numerous bridges which has taken place during the last Six Years under all sorts of contingencies; it is gratifying to find that in two cases only accidents have happened Both of these cases shew in a remarkable degree, the evils of inattention to the proper use

use of mortar in seams, and are curiously illustrative of the questions discussed in the foregoing paragraphs. The two exceptions to which I refer took place in the building of the Dinas and the Bhosan Bridges, the former under Class I and situated at the 32nd Mile of the Main Trunk, the latter under Class 5 at the 145th Mile of the Cawnpoor Terminal Line.-

In the 1st Case, the Arches 55 feet Span were built on timber centerings with Material of the very best description, and under the eye of an Assistant Executive Officer. The Arches were Keyed as usual, and the process of striking the centerings commenced.. So great was the quantity of Mortar used that the Arches literally followed the Centerings in their gradual depression, and had the Timber work been entirely removed would have fallen to the ground. This was prevented by their resting on the frame work. After the depression had proceeded to an extravagant extent, ~~when~~ the Masonry was pulled to pieces. At the period when this occurred I was too far off to visit the spot, but I directed the assem-blage of Engineer Officers in Committee to report on the causes of failure.. The Presidents report is sufficiently interesting to

give

give it admission into the Ap-
-pendix, where it will be found
marked K.—

The results were arrived
at without demurrer; the Abut
-ments were sound and not
disarranged in the slightest
degree; the accident had occured
simply from an over abundant
use of mortar in laying in
the courses of brick work in
the arch.—

The 2nd Example occurred
in a small Single arched bridge
with a Span of 30 feet, the only
bridge on the Ganges Canal works
that had been Entrusted by an
Executive Engineer to a Contractor;
the Contractor however, was over-
-looked by a Native Sub Assistant
Civil Engineer. On this case im-
-mediately the Centering was
removed, the left impost block with
its Superstructure and Towing path
passage in its rear, slipped away
and the arch fell to the ground.
This was a quick and unmistake-
-able case of "Slipping of horizon-
-tal courses of Masonry". The Abut-
-ment below the slipping surface
was uninjured, and as this was
an especial part of the Enquiry,
I may observe that no trace of
yielding or action upon it in the
slightest degree could be dis-
-covered. On examining the
causes of this accident, it ap-
-peared that that part of the
abutment on which the impost
block rested, was literally made
of rubbish. The Executive Engineer

of

of the Division reported "the
"cause as it appeared to me of
"this accident was solely the very
"bad quality of the Masonry in
"the backing of the Arch, and
"in the great quantity of Mortar
"used, and in the very inferior
"quality of this Mortar" It ap-
-peared that this Contractor had
only built the Arches and Skew
-backs, the Substructure having
been completed by the Subassistant
Civil Engineer. In addition to
the Contractors bad work as leading
to the failure above described,
the Masonry had not been
allowed a sufficient time for
induration.

The Bridge at Bhosan
is one of a series built under
great difficulties of resources,
and a want of Material which
placed the Executive Engineer at
his wits end. The Abutment
walls of the Bridge in question
have no counterforts in their rear,
they rest upon the virgin soil,
which in all this part of the
Canal is of the compact and
retentive nature that I have
before described it to be. Diagram
CXVII, Fig 2, of this Chapter is an
exact representation of a section
of these Abutments shewing the
position of the Towing Path
Passage, in the present case
unsupported by Masonry walls,
but imbedded in a Soil I should
say as incompressible as Ma-
-sonry.—

It

It is perfectly evident however, that the value of this method of construction and de=sign depends entirely upon the Abutment being placed in close approximation and in direct contact with the virgin Soil, and that if a hairs breadth of Space is left between them, the Abutment becomes isolated, and is no longer in dependance upon one of its elements of support. Again, in making Excavations for foundation walls, the Masonry must rest upon the virgin Soil; excess of Excavation refilled by loose earth so as to bring the Cubic content of work built on a par with that of the Estimate, is if anything more dangerous and detrimental to the Stability of a Structure than that before alluded to; and yet in works under the management of European Overseers, I have had reiteratedly to notice cases in which both the above errors had been com=mitted.. In closing this Section therefore, and in addressing myself to men of the above Class, I shall repeat in the words of one of my Circulars "I would here draw "attention to the necessity in Ex= "cavating foundations to dig "the Earth as closely as possible "to the true dimensions of either "foundation wall, Abutments, or "retaining wall that comes in "contact with it; if a narrow "Space is left between an abut= "ment and Soil, the former

becomes

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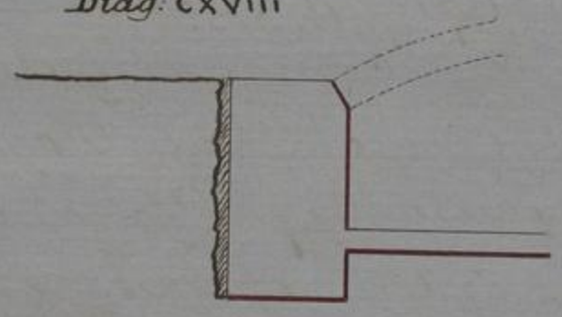
"becomes isolated, and derives
"no sort of benefit from a con-
"tact which is intended to be
"of the utmost service. For
"instance taking the following
"diagram of the Abutment
"of a bridge; if the Space
"marked in Shade is left hollow,

Diag: CXVIII



"or only loosely filled with earth
"the Masonry derives no aid
"whatever from the Soil, and the
"Abutment loses all the advantage
"in its opposition to the thrust
"of the arch which it ought pro-
"perly to derive from being
"backed by a rigid mass. This
"hollow Space ought in no in-
"stance to be allowed, and if
"the excavation is greater than
"the width of the Abutment, the
"whole of the Space excavated
"ought to be filled with Masonry

"The same remark applies
"to depths of Excavation for
"foundations: where this has been
"carried to excess, the whole ought
"to be filled in with Masonry:
"to use loose or imperfectly
"rammed earth is tantamount
"to ruining a building —

"The use of abundance
"of water in Rubble or bricklaying
"is as indispensable to the goodness
"of work as thinness of seams of
"mortar, and thinness of plaster to
its

"its durability"

In concluding this Chapter, I may observe that it has been an object in all the designs of Bridges as well as of works in general which are connected with the Canal Channel, to accompany them by means of access to the water. In cases where Revetments are required such Revet=ments have been commonly de=signed in the form of Ghats; Rajbuha Heads are universally protected in front by lines of this species of stepped Revetment, and to the whole of the Bridges, with very few exceptions, Ghats or flights of steps have been attached. At those Bridges which are crossed by the leading and high Military roads of the Country, or at those which are sit=ted near large Towns or leading places of resort, very extended lines of Ghat have been appended, so that Travellers and Foreigners who come in contact with the works of the Ganges Canal may appreciate an undertaking which has been designed for the benefit of the general commun=ity, as well as for that of the Agri=cultural population in its neighbor=hood. In designing the Ghats whether at Bridges or elsewhere, my intention has been to open them to the free and unimpeded use of all, whether Travellers, or village people, to whom they will offer the greatest of all Luxuries in an Indian Climate - bathing:- and to the Hindoo popu=lation the greatest of all possible advantages in this world - access to Gunga Mai. —

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CHAPTER, IV.

Works of Accommodation.

The object of these buildings is to provide accommodation to the Supervising Officers in their progress of Inspection, and to the Establishment in charge of the works, the water course heads, and the Irrigation.—

They have been designed on plans which are figured in Plates LIV and LV of the Atlas, and consist of two species of buildings, which are denominated 1st and 2nd Class "Chokies", or in plain English "Station Posts".—

The 1st Class Chokies, have a centre room 20 feet Square, with an Inclosed Veranda round it, of 10 feet in width, the veranda being divided off into rooms with porches on two sides which open into the Centre with which a room on the 3rd Side is connected; on the 4th side a Separate room is devoted to the accommodation of a Subordinate, in the Event of the Centre room being occupied by the Superior Officer. The rest of the Veranda accommodation is for the purpose of Store rooms and places of residence for the Canal native Establishment.

The 2nd Class Chokies are similar buildings, without the Veranda, or outer Inclosure, their dimensions, properly speaking, were designed at 18 feet Square on which they have generally been built: in some cases, however, this has been reduced to 18' x 14', and in others increased to 20 feet square.

the

the latter in cases where the attach-
-ment of an outer veranda, so as
to convert the building into one of
the 1st class, has been contemplated
These buildings are for the residence
of the Chokidars and Native Estab-
-lishment, and for the protection of
tools and Stores.-

The whole of these buildings
whether 1st or 2nd Class, have flat
roofs; the object having been to
avoid as far as possible, the con-
-tingencies of fire, to which thatched
roofs are liable - They are with few
exceptions built of refuse material,
that is to say of the half-burnt
bricks which remain in kilns
after the works directly connected
with the Canal Channel had been
completed; the cementing ingredient
is mud: both externally and in-
-ternally, however, they are stuccoed
or plastered with Lime Cement.-
In the language of the Department
of Public Works in these Provinces,
they are built of "Kucha Pukka"
Brick and Mud, the brick being
what is called "Pella" or half burned.-

Their position relatively to
the works is uniform: this is on
the left or roadway bank, on the
upStream side of bridges; at a
distance from the edge of the water
of not less than 100 feet, and from
the Bridge ramp not less than
100, or more than 300 feet.- Their
floorings are well raised from the
surface of the earth, in no case
less than 1 foot, and in the South-
-ern divisions where the Country
is ~~liable to inundations and to~~ flat
~~slow drainage~~, as well as in other
parts of the Canal where dampness
is a characteristic of the country,
the plinths of the Chokies have
been

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been laid on a level with those of the pillars and parapets of the bridges to which they are attached. As a general rule these Chokies are well raised and the accommo=dation is free from all the incon=veniences to which similar build=ings have been subjected on the Ahmna Canals, from the want of Elevation. -

In cases where 1st Class Chokies have been built in connection with Falls and Locks; their situation is centrical between the main and Navigable Canals, and on the up=stream side of the road that connects the Bridges which have been built over the works. -

The general position of these buildings has been determined with reference to the supervision of the Rajbuhs or water course heads in their immediate vicinity; and their position relatively to the bridge viz^t: on its upstream side, has been selected, that advantage might be taken of the prevalent direction of the winds which during the dry season, would blow the dust on the bridge ramps away from the Choki, instead of towards it; a consideration of no little importance to the convenience and comfort of the residents in the Choki. -

The 1st Class Chokies, have been built all the way down the line of the Canal and its branches at distances of about 12 miles, or varying from 12 to 15 miles apart. the specific object for which they have been built, and on which their distances from each other, have been determined, is to keep up an open line of communication from one end of the works to the other

other; to afford the means at all seasons of the year, for either the Inspecting or Executive Officers, to visit at the shortest notice any point of the works which require his presence, and to relieve both the Government, and the superviseing Establishment from the evils and inconveniences which during the rainy months, might arise from difficulties in marching and moveing, were no accommodation of this sort provided. —

With the above object in view, it will be clear that these buildings are not intended as private residences or for the occupation of the European members of the Establishment beyond limited periods; Permanent residence, or occupation for lengthened periods would evidently defeat the object for which the buildings have been erected; the Chain of Open posts, by which the maintenance of a connected line is contemplated would no longer exist, were even one of these buildings occupied by a family, or by an individual whether connected with the Canal Establishment or not; and considering that the purposes for which the Government has been advised to erect these buildings are entirely of a specific nature, the conversion of the accommodation which they provide to objects foreign to the intention on which they were built, can hardly be too rigorously protested against. The rule that has been usually observed on the Punnuar Canals with reference to Chokis occupation, is that the parts of the building which are expressly intended for the Commissioned and Non Commissioned Staff, should

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should be reserved for their accom=
=modation; but, that in the absence
of the former, the Non Commissioned
Staff may use that part of the
building which is intended for
the Superior grade, on certain con=
=ditions solely appertaining to pro=
=tection of property and cleanliness
of occupation. - Juniors in either
grade are supposed to give way
to Seniors, and unless under specific
orders in writing no individual
is expected to hold residence beyond
2 days. In every case it is expected
moreover, that people who take
advantage of the accommodation
should consider themselves answer=
=able for the property; for the glass
in the windows; and for the general
preservation from injury of the house
and its appendages. -

The case is one, however, +
upon which it is impossible to
lay down determinate rules; +
heavy repairs during a period
of the year when a European is
called upon to move out to a
distant Chokie, may detain him
for an indefinite period as a +
resident in one of these buildings.
in such a case, the building could
hardly be considered as turned
from its legitimate uses. Heavy
work, or matters connected with
Revenue might detain either the
Director or any of the Executives
for an equally indefinite time at
one of these Chokies; under such
circumstances a continued oc=
=cupation would be perfectly
fair - The object being understood,
it appears to me, to be sufficient
to carry it out according to its true
Spirit, abiding as far as possible

by

by written Rules which emanating from the Directors Office, would be the code for general guidance

These rules ought to be hung up both in the centre room, and in that one in the veranda occupied by the Non commissioned Staff, of every 1st Class Chokie; and the Chokidars or Chupprassi in charge ought to be made respon-sible for the furniture, glass, doors windows, and the state of the building generally; reporting the dates of arrival and departure of every person who occupies the building; and noting the way in which the property has been treated. Unless stringent rules are laid down for the prevention of injury not only to the glass, furniture and wood-work, but to the stucco and walls of the building (laying aside the carelessness and indifference with which Government property is treated in some instances by people who ought to know better) the Servants attached to our Establishments whether private or public are fre-quently the cause of a wanton destruction to property, when such property does not belong to their Masters. It is necessary to prevent this, and it can only be prevented by active legislation.

The ground in the neighbor-hood of these 1st Class Chokies ought to be kept in order, clean, neat, and free from deformities of any description; above all things its drainage ought to be properly attended to, full conve-niences being provided in the Inlet which is attached to the Bridge works, and which is situ-ated

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=ated in the Choki yard. In all cases, however, I would look upon this Inlet as a secondary means of relief; if possible, advantage ought to be taken of the natural slopes of the country, and a spacious Channel ought to be excavated so as to carry the drainage water not only away from the Choki yard, but away from the Canal altogether. It will be understood from what I have said elsewhere in these pages that the object of the Inlet which is attached to bridges, is to relieve the Country from the water col=lected by the interposition of the Ramps of the Bridge, and by their interference with the drainage of the country. -

The proximity of the Mango Fruit Plantation which is in=tended to be an appendage to every 1st Class Choki, may be the means of adding greatly to the convenience, as well as to the ap=pearance of the Station. Under an Officer who takes an interest in the order in which his division is conducted, and in the state in which his buildings and their dependencies are maintained, the 1st Class Chokies and their ap=pended plantations are really most desirable places of resort; in exemplification of which, I could point out Stations on the Eastern Jumna Canal ~~which have been~~ established by Mr. Deputy Superintendent Brew of the Canal Department, and which, without any additional outlay, and merely with that natural attention, which is de=rived from the possession of a large development of the organ of

of order; are equal in neatness and tidyness to the most carefully watched private property.—

The area of ground appertaining to a 1st Class Chokie is equal to about 4 acres.—

The 2nd Class Chokies, are with a few exceptional cases (dependent on the absence of Ryburtus Roads) built at every Bridge on the line of the Canal and Branches, their position is similar to that of the 1st Class Chokies, and the elevation of their floorings above the level of the country has been fixed on the same rules that guided me in the larger buildings. These Chokies are expressly for the accommodation of the Chokidars in charge of the Irrigation, as well as for the Tools and Stores of which there are depots at every post; the main ones being at the 1st Class Chokies, and the subordinate ones ~~but~~ under charge of the Chokidars at the buildings now under review.— Independently of the control of the Irrigation, the works in the immediate neighborhood are under the charge of the Chokidars, and the position of the building relatively to the different works, with the means of cross communication afforded by the Bridges, give him every facility of access to both sides of the Canal, and, consequently, the best means of Supervision.

To the 2nd Class Chokies situated above the Narrow Fork no separate ground is attached, their site is within the Canal boundary, and their limits are marked by the boundary ditch.

Below

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Below the Narrow Fork and on both the Canal Feeder and Etawah Terminal Lines, where the Canal boundary is more limited in extent, extra ground has been taken in; so as to regu-late the positions of the Chokies with reference to the Budgets agreeably to the rules before described

I have described the Chokies as built of "Kucha Pukka" or of half burned and refuse bricks with Mud; This method of con-struction originated in the Hum-na Canal works, and was adopt-ed with a view to economy; it was perpetuated on the same grounds in the works of the Ganges Canal, where in addition to any advantage that might be derived from the measure as one of econo-my, the demand for well burnt bricks was so great, and in many situations the difficulties of pro-curing them in sufficient abundance for the works that had necessarily to be built with the very best material, was so notorious, that the Executive Officers were put to every devise-able shift to procure material at all.— In devoting the pucka or half burned bricks to the build-ing of Chokies therefore, we adopted a plan that expedited the com-pletion of these buildings, and at the same time disposed of a species of material, that would otherwise have been useless, or at any rate have been a dead loss to the Material Department

The Estimate of 1850 for Chokies built on the Main Line

and

and the 2 Branches into which it is divided at Nanoon, with the material above described, is in itself a very large item, the total amount called for, for the construction of buildings of this sort including both those of the 1st and 2nd Class, was as follows

1st Division	11445	4	1		
2nd Do.	18341	3	3		
3rd Do.	14621	11	5		
Total Cost of Chokies on the Main Canal				44408	2 9
Cawnpoor Branch	38328	8	11		
Etawah Do	43136	14	2		
Total cost of Chokies on the Branches				81465	7 1
Grand Total on the Main Canal & Forks Lines				125873	9 10

At the period when the above Estimate was drawn up, the evil of using the half burnt brick in that part of the building which was in connection with the soil, and liable therefore to the effects of moisture, had been prominently brought to notice, throughout the whole extent of the canal. In those Districts lying to the South, where the soil was impregnated with the reh or alkali to which I have before alluded, and where the bricks which had been made of this soil were of a very uncertain quality, the material had so completely failed, not only by the attacks of moisture, but even by the mere weathering of climate, that as far as the foundations or that part of the building terminating on the plinth or flooring was concerned, it had been determined in all cases where such could be done, to use a better description of material, and to reject the refuse or pukka brick entirely. This although a good determination

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in itself was not brought into practice until the greater number of the buildings had been completed, and even then in some cases, the absence of good brick, necessitated the Executive Officer to recur to the use of the inferior material. Latterly, however, the use of the half burned or refuse brick has been confined as much as possible to the superstructure.

With regard to the use of mud as a cementing ingredient the defects appear to me to be great, and necessarily increasing in proportion to the thickness of the seams; to the quantity of cement used; and consequently to the size of the brick, and to the care with which the brick laying is executed. Lime cement indurates, and is not liable to the effects of pressure after this induration has once taken place; mud cement on the contrary although it hardens in dry weather, gets soft in the wet, and during that period of the year when the rain is continuous, and when everything exposed to its influence is affected by moisture, the mud cement in imbibing this moisture becomes liable to the action of superincumbent pressure, which must tend greatly to the disarrangement of high walls, especially when such walls have the weight of a roof upon them. The consequences of this disarrangement are exhibited in unequal settlement of the walls, in the action of doorway arches upon their impost blocks, and in a destruction to the integrity of the roof. Cheap, therefore, as buildings

may

may be, when constructed on the Kutcha Pukka principle, they are undoubtedly subject to the above evils, and although in nine cases out of ten careful supervision and the use of the large class of brick reduces these evils to a min=imum, they must always be impending over a building, where the material in all its parts is not rigid.—

I have in the following cases, substituted Lime for mud cement, at a very considerable excess of cost but with a view of testing the value of this original outlay, with that arising from the con=stant repairs to which the Kutcha Pukka Buildings are liable.— In the 3rd Division the following 1st Class Chokies are built with Lime Cement

Estimated Cost Mud Cement			Material		Position 1st Class Choki	Material		Actual Cost Lime Cement		
			Foundations	Superstructure		Foundations	Superstructure			
1216	5	4	Pukka Bricks	Pukka Bricks	Geesoofroor	Pukka Bricks	Pukka Bricks	1713	4	11
1416	5	4	do	do	Moondakhera	Pukka Bricks	Pukka Bricks	1696	6	3
1416	5	4	do	do	Kasimfroor	Block Kunkur	Pukka Bricks	1720	14	9

These station posts were built in the Cold weather of 1851/52.—

In the Etawah Branch the fol=lowing buildings have been constructed on the same principle.—

Estimated Cost Mud Cement			Material		Position 1st Class Choki	Material		Actual Cost Lime Cement		
			Foundations	Superstructure		Foundations	Superstructure			
1958	5	3	Pukka Bricks	Pukka Bricks	Puteekra	Kunkur	2 Cem Bricks	2576	14	—
361	13	6	do	do	Koosiarri	do	do	1472	2	11
361	13	6	do	do	Dohrja	do	do	521	4	8
361	13	6			Jowafroor	do	do	488	10	2
3043	13	9	Total			Total		4026	15	9

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It will be observed that in the Etawah Terminalline, kunkur has been used in some cases in the foundations only, in others in the whole building; the appearance of the Chokies built with kunkur is exceedingly good, the color is Cold, but it harmonizes with the hot weather feelings arising from an Indian climate. ~~Tried hardly observe that~~ Where this material has been used in the superstructure, stucco has been laid aside. -

A comparison between the Estimated and actual cost of the buildings above specified, as shewn by the Tables, will give a clue to the Amount of original outlay, that the use of Lime would have entailed on the Government, Whether such an outlay would have been warranted, is a question that must be tested hereafter, by the results of the annual repairs of the buildings constructed on the different systems, the excess of cost in the one being taken into consideration. -

It would appear from the above Tables that to have constructed the whole of the Chokies with Lime Cement instead of mud. the excess of cost would have been as follows: -

In Mr Volks Division

| | | |

3rd Division -	Maximum	Rs 9 - 0 - 1	pr 100 Cubic feet	
	Minimum	4 - 4 - 8½	pr do	
4th do	Maximum	10 - 4 - 10	pr do	Partly Pukka Work
	Minimum	5 - 0 - 7	pr do	
5th do	Maximum	9 - 10 - 9	pr do	Partly Pukka Work
	Minimum	6 - 3 - 3	pr do	

Wherever well burned bricks have been used, a note to that effect has been made opposite the rate: and this is a circumstance to which in drawing comparisons, most especial attention is required, the cost of well burned brick varying from 6 to 16 Rupees per thousand, whereas the cost of the Peela, or refuse ones is only 2 Rs 8 annas per thousand.

In conclusion I may observe that in the course of progress, improvements and, in some cases additions have been made, to the 1st Class buildings. In all the Divisions excepting the 2nd, the veranda roofs have been raised an additional foot, with the object of improving the accommodation and making the rooms cooler; In some cases and I much regret that it has not been done in all, a staircase has been made from the floor to the roof, so as to give easy access for repairs, and during hot weather the

the means of approach to the upper terrace, the elevation of which affords a very agreeable and airy promenade during the close and sultry Evenings of the hot weather.

In the 2nd Division, or that extending from the 21st to the 110th Mile, the Chokies have been constructed precisely on the same design as regards Elevation as that originally Estimated for. As a set off, however, against the economy of not raising the Veranda roofs as has been done elsewhere, the Executive Engineer has built to each 1st Class Choki a range of flat roofed outhouses, containing 5 Rooms of 10' x 8' each. The object of these buildings is to prevent either the European or Native Establishments, from disfiguring the neighborhood of the Choki with huts and temporary buildings the erection of which is in all cases prohibited. During the progress of the works, and it is during this period that the whole of my Directorship has been passed, it has been found necessary to allow the construction of temporary huts for the accommodation not only of the laborers, but of the Supervising Establishments. Our 1st Class Chokies have in many cases been built at points far ahead of the Excavation and works in progress so as to act as Nuclei and Head Quarter Stations to the Establishment, both European and Native in charge of the advanced work. These Arrangements necessary as they were at the time no longer exist

exist on the completion of the works for which they were expressly made, and ought therefore to be summarily abolished. It appears to me to be so desirable that the ground in the neighborhood of these chokies should be maintained in a neat and orderly state, that if the plan adopted in the 2nd Division of having a range of out offices attached to each building be one leading to such a consummation, I would strongly advocate its extension throughout the whole of the works. —

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CHAPTER V.

Works of Navigation

This Chapter is divided ~~Itself~~ into three sections:-

I.. Navigable Channels.-
II.. Do Heads.
III.. Do Locks.-

I shall, however, review them under one head as they are too intimately connected with each other to admit of convenient separation

In considering the term Navigable Canal in its accepted signification, viz^t.: a Channel with no current to impede, or delay the passage of craft, and with the levels completed in a series of still or nearly still reservoirs, the Canals in these Provinces, hold no claim to any consideration; nor would works constructed on such designs either be consistent with the objects in view, nor be beneficial to the Cultivators ~~for the point of~~ Irrigation.-

There is a medium, however, in which both objects may be gained; we may dispose of the current on a regimen capable of counteracting the evils to be expected from weeds, which either in a Tropical or Semitropical climate would inevitably attend upon Still water; and we may by lockage arrangements attached to the Masonry descents, provide ample means for the passage of boats.-

The Ganges Canal works which are Specifically for Irrigation come under the above category. The Channel is on its open course applicable

applicable in every way to the pas-
-sage of boats; the interruptions to this
open channel which are caused
by the Masonry descents, are counter-
-acted by lines of safe and com-
-modious transit, which being carried
in a circuitous direction and at
considerable distance from the
main Canal, are placed out of
the influence of the rapids. On these
circuitous lines the difference of
level is gained by Lockage, and
every convenience is afforded to the
passage of craft, both in facilita-
-ting its progress and in providing
for its security*.

As a navigable line under
the restrictions which the more im-
-portant objects of Irrigation impose
upon it, the Ganges Canal will afford
the means of water carriage from
the point where the main River
leaves the Mountains, through the
heart of the Northern Doab; it will
by regaining its parent stream at
Cawnpoor, offer a compact and safe
line of transit to the avoidance of
the shoals and rapids which are the
characteristic feature of the Main
River

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* When the Falls for regulating the levels of the new
were constructed on the Eastern Jumna Canal,
the Chamber on the left side was fitted
with Gates for the purpose of lockage; the plan
was inexpensive, attended by no interference
with the object for which the Falls were
built, and it demanded the mere applica-
-tion of upper and lower Gates, which if re-
-quired elsewhere might easily be removed; with
the exception however of the Locks in the
Southern Division, where the body of water was
comparatively small, and when the working of them
was under the eye of one of our best overseers, none
of these Locks have been used. The danger arising
from the proximity of the Lock Channel to the
open overfalls, and the fear of being engulphed
in the latter, may possibly be the cause ~~Imagine~~ of the non
acceptance of the Eastern Jumna Canal as a line
of water carriage. The remedy, if this is the case, is by
a side channel as at the open on the Ganges Canal
Works above described.—

River; by its junction with the Jumna near Rumeepoor and Kalpi, a new link will be provided to the water carriage of the country, and as I have remarked elsewhere, its relative position to all the Rivers that run parallel to it, provides the means of still further extending its usefulness, by the adaptation of locked Channels, and by their means connecting the inland Towns or commercial Marts with the Nav=igable Rivers.—

Dawson

I have drawn attention to a navigable branch that might be constructed from the main Canal near Moradnuggur to the Hindun River; as well as to one that might be taken from the Bolundshuhur Branch, via Belasposr to the Jumna River, both these lines would reach the Jumna at points nearly iden=tical, the former having the disad=vantage of having had to navi=gate the tortuous course of the Hindun River; the latter having been altogether confined to artifici=al and, therefore, compact lines. Both of them open out new lines of Country to which the means of water carriage would be ac=ceptable; and both of them, there=fore, are perhaps worthy of con=sideration. By looking at the map however, it will be evident that there is no limit to the means provided for the adaptation of the Canal to water roads, and to their being linked on to the side Rivers. the Rajbuhas even in themselves will I doubt not become the me=dium of providing the Inland villages with Bill Produce, es=pecially with the smaller class of rafter for house building which is

is now unattainable from the cost of land caniage.-

Before entering upon the detail of construction and design of the different works to which this Chapter is devoted, it will be necessary to explain the especial objects by which I was guided in their elaboration. The changes that have taken place in the disposition of the works in the Khadir, sufficiently account for the redisposal of the Channels for navigation; to the works, therefore, that have actually been built, I shall confine myself, and these (with the exceptions ~~of~~ ~~the~~ above noted) are similar in general respects to those of the 1815 Estimate.-

In the design for the Navi-gable Channels I was guided by the following considerations.-

1st The necessity of an alignement at a sufficient distance from the works on the main Canal, to pre-vent either one or the other from being incommoded by too close a proximity.-

2nd To place the point of departure of the navigable from the main Line at such a distance from the Falls, that it might be en-tirely free from their influence.-

3rd To protect the Head of the navigable Channel, and to make the best arrangements for securing the safe admission of Craft.-

4th To adapt Corn Mills to the waste Channel of the Locks, and to make it generally ap-plicable to the purposes of Machinery

5th To combine with the Masonry works attached to the Locks, such

such Inlets for drainage, and such outlets for Irrigation as might be required from that particular part of the Canal in which the works were construc-ted.—

The dimensions of the Channel as well as those of the Lock Chambers were determined on the length of the largest sort of Kurri or rafter into which the Saul Timbers of the Forest are cut up for the country markets. This species of wood which varies from 10 to 15 feet in length and from 3 to 6 inches in Scantling, is sold in enormous quantities, and is in general use throughout the North western provinces, wherever it can be obtained at a reasonable price. It is collected at Mauts situated on the banks of the great Rivers in the neighborhood of the Forests, and from thence it is floated down on rafts to Depots, from whence it is distributed over the country The Kurries of 15 feet are tied side by side and form longitudinal Rafts frequently of immense length, but in width confined to the length of the Kurri. By making the Navi-gable Canal Channel, Therefore, Equal in dimensions to the Section which I have shewn in Diagram
121 CXXI and by designing the lock Chambers on a width of 16 feet, I gave every facility to the passage of the same Species of raft that now traverses the main Rivers: I avoided the necessity for alteration in the form of rafts, and I did not demand any change in the method to which the boat people and rafters have been accustomed. — By giving

a length of 100 feet in the clear to the Lock Chamber, the size of raft which will be able to pass down the Canal will be equal to the average of those which are now floated down the Ganges. The width is a convenient one and admits of the utmost simplicity in the gate and sluice apparatus.

The Question of the greatest importance after the dimensions of the Channels and Lock Chambers were decided on, appeared to be that which comes under the 3rd Item; it was very clear that to consider the main line as a navigable one, with the prospect of boats or rafts being brought in contact with the Falls, was unreasonable. It mattered little whether through carelessness or accident boats were overwhelmed in these Cataracts; catastrophes of this sort were to be avoided. The notorious ~~indifference~~ apathy of native boatmen was well known, the carelessness and neglect of Establishments were contingencies of too frequent occurrence to be treated with ~~indifference~~ inattention, and the possibility of craft passing the navigable head, and proceeding onwards towards the Falls was obviously a matter to be guarded against. It was a case in which no half measures would answer, and one in which the prevention to danger ought to be so certain, that no reasonable contingency should be likely to defeat it.

The original idea was to throw Chain booms over the main Canal immediately on the down stream side and below the head of the navigable channel; the

objections to this plan, however, were the uncertainty of obstruction that booms would offer; especially under the extreme variations of high water level to which the Canal was subjected; there was much in the practical detail, moreover, of the design, that rendered its adoption inconvenient, and the mere facts of doubts existing as to its sufficiency appeared to me to be fatal to a project upon which the security of property, and even of human life depended. - In lieu, therefore, of Chain cables suspended across the main channel a bridge of boats has been substituted: the passage of traffic therefore, is entirely confined to the open channel above the bridge which acts as a finger post in directing the boatmen to the navigable Canal head, and opposes a direct bar to the advance of craft beyond the limits of safety. The Bridge itself although not designed as a high road for communication, affords the means of crossing the main channel and of placing the Canal Establishment in connection with a Rajbuha Head which is situated on the right Embankment, and on the upstream side of the bridge. the Bridge, moreover, will to a certain degree act as a bund and by retaining the water on the upstream side on somewhat higher levels, give to both the Rajbuha Head on the right bank, and to the navigable Channel on the left the advantages attendant thereupon.

The works under this design offer a security to boats in their passage which otherwise they would not

not have had; the chances of accident are indefinitely removed and the advantages arising both to Irrigation and navigation appear to me to be conclusive as to their fitness for the purposes required.—

I now proceed to the detail of the navigable lines and the different works therewith connected.— In their order of precedence those in the Ganges Khadir will be first described, and to do this satisfactorily I must introduce a repetition of Diagram XIV, Fig 2, which was formerly given as illustrative of the change that had been made in the disposition of the works between the Ranipoor and Puttri Torrents.—

The object of the navigable Channel in the Khadir is to overcome a descent of 36 feet that occurs between the Ranipoor and Puttri Superpassages. The distance between the two works or between the Extremes of the high and low level is only 4·6 Miles; it was considered, therefore, expedient to design the whole in one uninterrupted Channel for navigation, instead of in a detailed series appended to each particular descent The navigable Channel, ~~accordingly~~ ~~therefore~~ which

which leaves the Main Canal on its left bank immediately on the upstream side of the Dowalaswr Bridge, runs parallel to it, impinges on the superpassage at Ramipoor under which its channel is carried, and from thence gaining its parallelism, meets the Main Canal below the Puttri Superpassage under which its course is conducted on the same design as that at Ramipoor.—

The Dowalaswr bridge acts towards the head of this line of Navigation, in the same way that the Bridges of boats before described are intended to act at points where there are no Masonry bridges. It offers a marked and decided limit to the water available for Navigation, it is far removed from the head of the Falls, and by occupying each bay which is 55 feet in width by 3 boats anchored, and firmly held in position, so as to prevent the passage of Craft beyond its limits, we shall secure our object, with the smallest possible interference, and with as little obstruction as could well be, with the passage of the water in the Main Canal.—

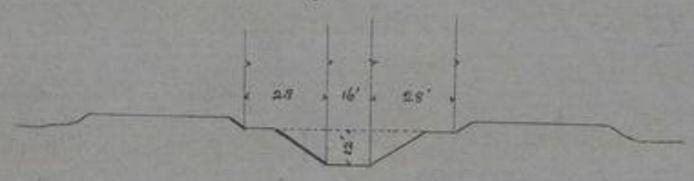
The Head of the Navigable Cut — consists of an arched Masonry Channel 20 feet in width giving cover to a Towing path of 5 feet, and a water Channel of 15 feet in width; this Channel passes obliquely through the Bridge Wings and ramps leaving the Main Canal at an angle of 40 degrees. Drop Gates are fitted to the front, so as to admit of the Channel being kept dry for re-
pairs

=pairs or for other contingent causes;
and the entrance into the arched
Channel is ~~covered by~~ flanked by
Masonry walls, with piling and
the necessary expedients for pro-
=tecting the work from injury.
The whole forms a component
part of the Dowalla[illegible] bridge
to which it becomes a leading
feature on the upstream left
flank, the remaining three +
flanks being covered by the +
Dalhousie Ghats. —

The work with the exception
of the foundations and the more
solid parts of the abutments in
which boulder Masonry is used
is constructed entirely of brick
The arch, which is a Segment of
60°, is sufficiently elevated to
admit of free passage for loaded
boats with a maximum supply
of water in the Canal: (vide
Atlas Plate XVIII Fig. IV)

After leaving the Masonry
head above described the Chan-
=nel which is excavated in a
soil somewhat sandy and
on the following section

Diag: CXX.



proceeds for a distance of 1839·66 feet on a
curve with a radius of 2256 feet; it is then
carried for 4868 feet (of 600 feet) parallel
to, and at a distance from the
Canal boundary until it reaches
the neighborhood of the Ramjoor
Superpassage immediately in
front of which the 1st Series of locks
is established. At a distance of
615 feet from the upstream
face

face of the Superpassage works, a revetted and floored Masonry Channel 16 feet in width, at its commencement; directed upon the works in a ~~Segmental~~ Curve form, delivers the water on the head of the Lock Chamber, at which point the width of the Channel has increased to 30 feet. This Masonry Channel which commences immediately below an octagon harbour or resting place into which the navigable Channel is directed, is entered under a Masonry Bridge with a Segmental arch (60°) of 25 feet in width, 9 feet of which is occupied by a Towing Path. The Channel then sweeps round a 1st Class Choki which is situated in an elevated position on the right, and between which and the Channel access is gained by a flight of Steps, and proceeds onwards. On the approach to the head of the Lock, this Masonry Channel throws off a branch running parallel to it, and passing under the floorings of the Superpassage, in the same way although on a higher level than that of the navigable line. Both these Channels form flank archways designed uniformly with those for the passage of the water in the Main Canal, from which they are separated by a Masonry revetment. The Archway for the navigable line is 19 feet in width; and that for the parallel passage which is intended for the supply of Corn Mills at Bahadooraban is 10 feet. Both the supply heads of the Corn Mills and the passage for boats are thus brought to bear upon the Rajnipoor Superpassage, of which they form component parts; the floods

floods of the Torent passing over the whole, without in any way interfering with their respective Channels.-

The height of the Revetment or wall that Separates the navi-gable passage and the Lock Chamber from the main Canal Channel is 15½ feet the width giving space on the side towards the main Stream for a parapet of 3 feet in height. The difference in width between the Lock Chamber which is 16 feet, and that of the Archway under the Superpassage in prolongation of the Lock Chamber which is 19 feet in width, has enabled me to terminate the Revetment of Separation above described by a flight of Steps, connecting the higher with the lower levels, and giving access to the navigable Channel under the Archway.-

For the purpose of regulating the supply in the Channel 3 Sluice openings of 6 feet in width have been pierced through the Separating Revetment, at a point immediately above the Head of the Lock Chamber.-

For the general design of the Locks themselves with the detail of the apparatus for fixing the gates, filling and emptying the Chambers &c I am indebted to my visit to, and to my Inspection of the works of this description in Lombardy - There can be no difference of opinion on the extreme simplicity of these designs which will be better understood by reference to the atlas Plate XXIII The upper Gates which are comparatively small being in height 6½ feet, are held in position by a plain wooden

wooden cross, in the place of the complicated collars: and the lower ones for the retention of which in their proper position greater care is required, are immoveably fixed by a timber laid transversely across the Chamber, capping the upper pivots of the gates, and having its ends embedded in the Masonry work; by embedded, it is not meant that the Timber is irremoveably built into the Masonry, it is merely laid in grooves adapted to its reception, and out of these grooves it can be removed and the gates displaced, without the slightest disarangement to the building. In both the upper and lower gates, the lower pivots are seated in the usual way in Stone blocks, in the present case the blocks are of the Delhi Quartz rock; they are in fact corbels from the ruins of old Delhi. -

The same Corbels have (fixed in an upright position) been used as bumping Stones for the gates to shut upon; this plan has been adopted universally in the room of the unbroken in use both in England and Lombardy which it was supposed would lead to interruption in the working of the gates, by collecting sand deposits -

The Sluices for filling and emptying the Chambers, the simplicity of which attracted my attention when on the Pavia Canal more than anything else that I observed on the Italian Canal works: are really exaggerated stop Cocks; that is to say Solid cylinders pierced through on one side

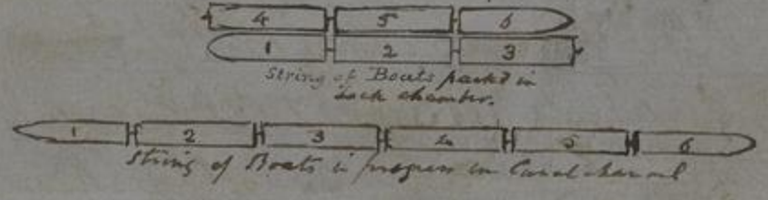
side, so that when the side that is pierced is opposed to the Chan-nel, water Escapes; by turning the Cylinder and opposing to the water the unpierced side the sluice is closed.- From the shape of this machine which is Cylindrical and measuring 2½ feet in diameter by 3½ feet in height, we have for want of a better called it a "drum "sluice"; it is worked by an up-right axle which is carried up through the Revetment and is terminated by a handle or lever fixed at right angles to it.- As in the case of the lock gates its lower pivot works upon a stone block. (vide Atlas Plates XXIII Fig 4) These Sluices are fixed on a low level, so that when the admission of water into the Chamber is re-quired, every advantage is de-rived from Head pressure and by this, to rapidity in filling the Chamber.-

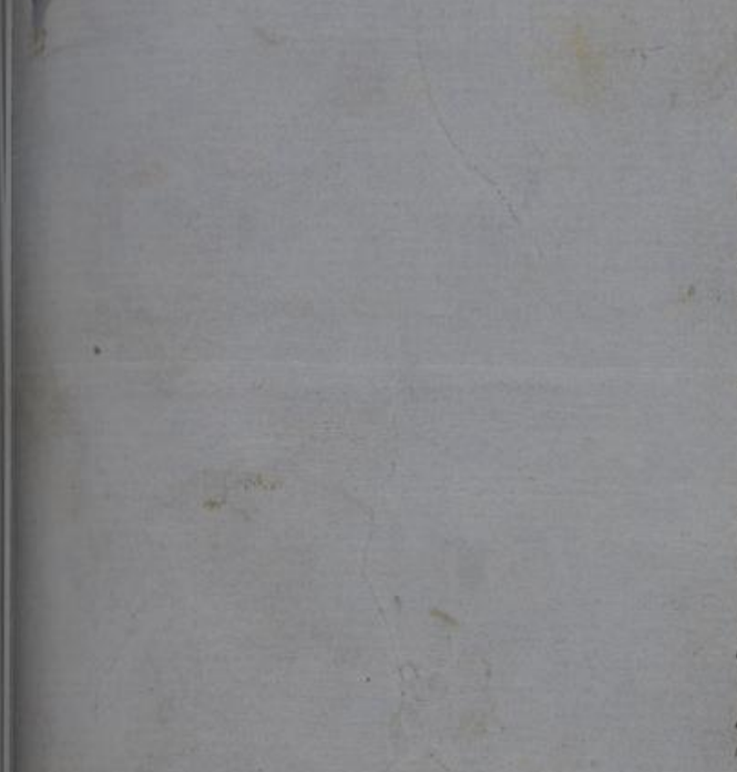
The ease with which these Sluices are worked, their utter independence from all rackwork, Chains, in fact from all vertical motion; renders them of extraor-dinary value on works, which are entrusted to the charge of simple and uneducated Es-tablishment.- I may remark also that the adaptation of com-plicated machinery, or simple machinery even, which is liable to disarrangement, might be fatal to the use of works of this sort, in the absence of means for its immediate repair.—

A Question, however, still remains, dependant in a great measure on the horizontal move-ment which appears to be so admirably

admirably adapted to security, May not the Sand and Silt de-=posits, which are to be expected in the Ganges Canal works affect the working of these Sluices? Even this evil, ~~however~~, should it occur, may perhaps be remedied by a Standing order for turning them twice or thrice a day, should the locks be out of Employ.-

The dimensions of the Lock Chambers are 16 feet in width on a total length of 100 feet, the drop being 9 feet in perpendicular height with a reservoir at its foot;- the width is adapted to the larger sort of Kurri or rafts of 13 feet in length, and to the raft which is used on the Ganges as before explained. It is also adapted to a String of boats as proposed to be used for the transport of material &c on the works, the design of which is shewn in the following diagram

Diag: CXXI.

I have adopted the Timber apron as shewn in the diagram at X X, for the purpose of keeping the boats clear of the drop, and for breaking the fall when water is permitted to pass over in large bodies. This apron is used in all the Lock Chambers that I visited in Northern Italy, and its ad-=vantages were so highly spoken of by the Engineers who accompa-=nied



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-nied me, that I have no doubt,
time and practice will prove
its applicability on the works
in these Provinces.—

The whole of these buildings
are with the exception of the
more massive parts of the Abut-
-ments and foundations which
are of boulders, built entirely
of brick masonry; the lining
out of the curves of approach
to the Superpassage has been
admirably executed by Mr Kay
the assistant Engineer in charge
of the works, and the bricklaying
and work in general ~~has~~ have been
well done.—

On leaving the Superpassage
a masonry Channel carried on
a ~~—~~ curve similar to that on
which the Navigable line reaches
the work delivers the water on an
excavated Canal which runs on
(first on a curve, 1010 feet in length, and then)
the left parallel to and at a
distance of 531 feet from the main
Canal boundary. The length
of this ~~curve~~ curve and of the
masonry Channel from the down-
-stream face of the Superpassage
to its termination on the Earthwork
is equal to 435 feet. The above
masonry Channel, the Revetments
of which are 12·65 feet in height,
is crossed by an aqueduct for
conducting the Mill Supply
which up to this point runs
parallel, although as it will
be understood from the purpose
for which it is intended on a
much higher level.—

Shortly after the masonry
works in connection with the
Superpassage are left, the excа-
-vated Channel is widened
out

out into an Octagon reservoir for the purpose of acting as a harbour and resting place for boats on their reaching the Lock passage.- At a distance of 4140 feet in advance, the 4 Bahadoorabad Mills which lie on both sides of the navigable Channel, are passed under an Aqueduct; and in advance of these again at a distance of 3334½ feet are No 2 Locks the Bridge over which, has its axis in pro-=longation of that of the Falls' Bridge over the Main Canal; a method of alignement which has been designed for all the works connected with navigation -

The works at No 2 Locks consist of a Lock Chamber with its dimensions and fittings of the same plan as those before described - On the right of the Lock Channel is a waste one 11 feet in width to which the necessary appliances for regulating the Escape water have been attached Both Channels are crossed by Masonry Segmental arches, form-=ing a bridge with a roadway 25 feet in width between the plinths of the parapets. The Lock and the waste Chamber are separated by a wall which gives a platform on its top of 9 feet in width - On the down-=stream side this platform is terminated by a flight of steps affording the means of ap-=proach to the water from the bridge roadway. - The side or Abutment Revetments are ter-=minated both on the up and down Stream extremities by

Sweeps

sweeps, which are well covered by the slopes of the excavated Channel.-

An open line of Canal in prolongation of that before described, delivers the water on No 3 Locks the position of which relatively to No 3 Falls on the Main Canal is uniform with that before described. With the exception of the bridge roadway which is 15 feet, the works at No 3 Locks are similar in every respect to those at No 2.- their dimensions and design are identical.-

At a distance of 600 feet, the excavated channel retains its parallelism to the main line of Canal, arriving at the Puttri Superpassage precisely under the same conditions as regards alignement and works as it did on its approach to the Ranipoor Torrent.-

The curved Masonry Channel which is 599½ ~~600~~ feet in length from its commencement to the upstream face of the Puttri Superpassage is entered under a Masonry bridge similar to that at Ranipoor. the Channel sweeps round a 1st Class Choki which is situated in an elevated position on its right, the higher platform being connected with the water by a flight of steps: the Lock both in its position and appurtenances is precisely the same as that at the Ranipoor works; the only difference that exists being that the Lock Chamber delivers the water into a Channel of 25 feet in width

instead

instead of into one of 19, and that consequently the revetment separating the navigable from the Main Canal is 13½ instead of 7·4 feet, and the flight of steps 9 instead of 3 feet.- The difference in the design of the Works in the above respect is purely accidental - At the Ranipoor works we were restricted within limits bounded by the Inlet and outlets that had been previously built. At the Puttri works we were unshackled; we had, moreover, at the Ranipoor works to arrange for a passage for the Mile water for the Bahadoorabad Mills, a necessity that did not exist at the Puttri works where with the exception of the Archway required for the purpose of the Navigable Canal the work was devoted entirely to the passage of the main stream.-

Wilcocks

On passing the lock, the boats are delivered on the lower levels into the main Canal.- They have in the 4 Locks already passed, overcome a descent of 36 feet - From the left Channel therefore of the Puttri works the Navigable Canal is absorbed into the Main stream down which the boats proceed without any further interuption until they reach the high land of the Doab.

The Channel and Lock works at the Puttri are entirely built of brick Masonry with the exception of portions of the most massive parts of the structure in which boulders have been used - This in fact is the character of all the Masonry works

works attached to this line of
Navigation, externally they are
stuccoed or covered with a coat-
-ing of Lime Cement.—

From the head at Dowalla-
-poor down to within half a mile of the commence-
-ment of the Masonry Channel
at the Puttri, the excavation of
the Channel and foundations
for the works were not incom-
-moded by Spring water, and
were therefore executed without
the slightest inconvenience.-
The whole of the works connected
with the Puttri, however have been
laid in Springs, and have been
built under difficulties of no
ordinary nature.—

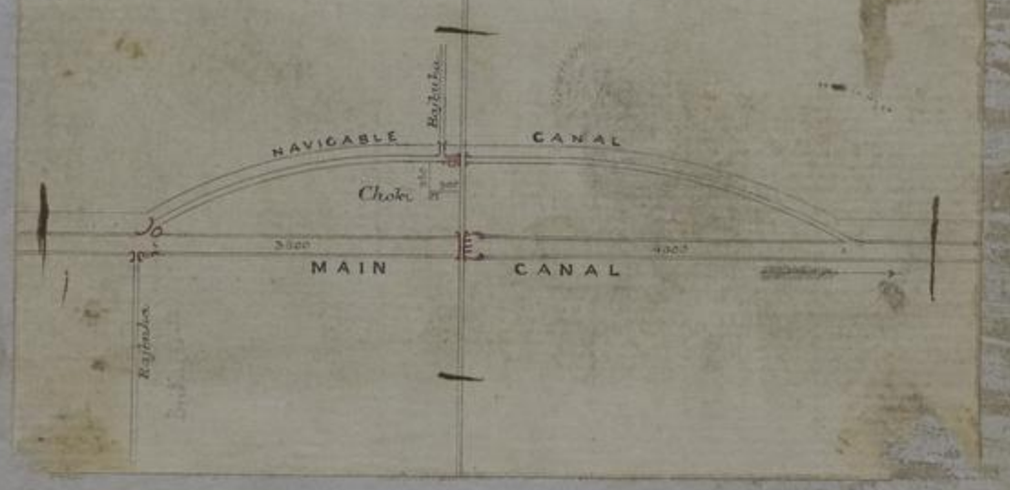
The former were constructed
under the Management of Mr Kay,
and the latter under that of Mr
Login, the Assistant Engineers,
to whose care the whole of the
works on this part of the Khadir
have been entrusted.—

From the above description
it will be understood that the
Lockage in the Khadir is confined
to the tract lying between Dowalla-
-poor and the Puttri, and that
on this distance the Channel
for Navigation continues uninter-
-ruptedly and on a course en-
-tirely distinct from the main
line of the Canal.—

We now come to the passage
of the Falls which lie below
Roorkee, or those on the highland
the description of which is given
in the 2nd Section of the 1st Part
of this history.— Here in contra-
-distinction to that above des-
-cribed, the Navigable passages
are carried round each descent
separately and they are necessarily
accompanied

accompanied by works of a some-
-what different description. The
following Diagram will shew
in detail the relative positions
of the navigable and main lines
of canal and the different works
attendant thereupon, under the
design which I am now about
to describe. —

Diag: CXXII



On the above plan the
passage of all the Falls lying
below those at the Puttis Supn.
-passage is effected. These works
are 10 in number and they extend
from the Assoffnuggur Falls which
are situated at the 24th Mile, to those
at Sirnia, the last of the series, and
which are built at the 164th Mile
from the Regulating Head at
Mysoor. —

The relative situations of these works
will be shewn by the following Table,
which exhibits in a parallel column
the Amount of drop which the change
of level necessitates at each of the Locks
which are appended to the different works

	Position on the Canal	Amount of Drop
Assoffnuggur Falls	24th Mile	8 feet
Mukmoodpoor	31 "	8 "
Bilra	42 "	8 "
Saoli	48 "	8 "
Chitowra	55 "	8 "
Sulawar	68 "	8 "
Bhola	84 "	8 "
Dasna	106 "	8 "
Pilra	129 "	5 "
Sirnia	164 "	5 "

210 Miles

The reasons why the Navigable Canal was not carried in one continuous line, and parallel to the main Stream as has been done in the Khadir, were the length of the extreme distance between the Head and the Tail of the descents; the great quantity of valuable ground that would have been occupied; and the expense that would have been incurred, not merely in additional Bridges for cross communication and in the Excavations originally required but in the after Maintenance of such an extended Channel.- On the other hand there were very great recommendations in favor of the continuous line; the head works of the cuts which with their bout bridges and appara-tus attached are expensive items in the cost of these works, would have been reduced from ten to two; the inconveniences which are anticipated from the silting up of the mouths of the Navigable cut heads would have been re-duced in a similar proportion. and there can be no doubt that an entirely detached passage would have been more secure for the transit of boats and rafts than the main Channel; but it must be taken into consideration, that the excavated line of the Navi-gable cut would under this Arrangement have either required to be of greater capacity, or it must have been fitted with numerous harbours or resting places, which, like sidings on Railroads, would have been necessary

for

for the free an uninterupted pas-
=sage of boats and rafts moving
up and down stream. In
balancing the advantages and
disadvantages of both methods
I determined on that which has
been adopted, and although
it would be a source of regret
to find my anticipations of its
benefits unrealized; I should
have the satisfaction of knowing
that the method I have rejected
is still available simply by
extending and prolonging the
earthen Channels.-

In the works, therefore,
connected with the detached
Falls which I am now about
to describe. the line A B formed
the axis on the centre of the bridges
of communication across the
Falls and Locks. From this axis
the entrance and exit of the
Navigable Channel are fixed
at 3500 & 4000 feet respectively from the head and
tail of the falls; a distance that
was supposed to be adequate
to removing these points out
of the influence of the rapids.
The main and Navigable
Canal are 1000 feet apart from
centre to centre, and they are
connected at the entrance and
exit by curves, as shewn in the
Sheet of the Atlas in which the
detail of projection is given -
The alignements, therefore, form
an Island, of which the length
is 7500, and the breadth 1000 feet
This inclosed tract is used for
Plantations, and as the site of the
Choki (in most instances a 1st
Class one) which is centrically
situated between the Navigable
and main Canal, and on the
upstream

upstream side of the road that con-
=nects them.-

The Head of the Navigable
Canal consists of an open Revetted
passage 16 feet in width, the left &
Revetment meeting the Earthwork
by Sweeps, and in some cases by flights
of steps. The right, or that which con-
=stitutes one side of the Inclosed
angle between the two streams, is
connected with a similar Revet-
ment, which forms the other, resting
on the left of the main Canal.-
These 2 Revetments, the one forming
the Right of the Entrance into the
Navigable Cut, and the other that
of the left flank of the main Canal,
meet each other at their Ends in
Circular Sweeps; the whole building
forming an oval narrower at
one end than at the other. that
end which is narrowest being
Salient towards the Stream.-

The Revetment which faces
the main Canal is fitted with
Iron Rings placed in three tiers,
which correspond with similar
appendages attached to a Revetment
built on the Right of the main
Canal.-

Between the two Revetments
a Bridge of Boats will be thrown,
held in position by Chains fixed
to the rings, and by Screw piles &
adapted to moorings in the Canal
bed.-

The object of the 3 tiers
of rings is to accommodate the
bridge to the fluctuations in the
rise and fall of the water, and the
Revetments to which the rings are
attached, are designed with flights of steps
on the upper 6 feet of their height
so as to give the means of approach
to the Bridge roadway under these
fluctuations.-

Attached

Cummins

Attached to the upstream side of the revetment on the right of the main Canal, is a Rajbaha Head. The connection between the two works has been formed in a variety of ways adapted to the particular position of the work. In some cases by flights of steps or Ghats, in others by a mere continuation of the wall

Cheesman

The passage into the navigable Canal is an open one, without arch; it is fitted with grooves and the necessary apparatus for shutting out the water, or regulating the supply; the planks or sleepers necessary for this purpose being used in the interim as a temporary means of communication across the passage. A shovel or moveable platform might with great advantage be adapted to this passage.—

I may observe in closing the description of these headworks, that a flight of steps is constructed in the salient end of the building which separates the two streams, by which means access is given to the upper platform of the work and to the Island at the point of separation of the Channels

The detail of the Boats and apparatus for fixing the Bridge in position, is left for future determination and adjustment; practice and experience will I have no doubt render this part of the design a simple one. In the meantime, I have adopted the Iron open boat in present use on the Canals in these Provinces, the dimensions of which are L

L 30½' X B 9⅔' X D 2¼'.. Seven of these with intermediate platforms will be required at each of the heads from the Assoffnuggur to the Dasna works.- The Bridges at Pulra & and Simra where the Main Canal is reduced in width, will not re=quire more than Six boats each.- I have preferred boats to pontoon Cylinders, because the former are available for all sorts of useful pur=poses. whereas the latter are limited to one.- By using the same sort of boat, in the Bridges that is used on the Canal generally, for the transit of goods, there would be less fear of interuption in the event of re=pair.- These Bridges, moreover, might be considered as the Hospital for craft which had seen better days, and whose time might be more valuably spent in retirement than in the active duties of its profession.—

The Locks and ~~its~~ waste Channels are identical in every way excepting in height with those that I have before described as built at No 2 and No 3 of the Khadir Series.- The depth of the Revetments ~~vary~~ varies with the Theoret=ical maximum high water mark in the Canal; for instance from Assoffnuggur to Davli where the maximum high water is 10 feet from the Canal bed, the Revetments on the upper sill of the Lock are 11 feet.- From Chitorna to Dasna inclusive the theoretical depth of the water being 9 feet, the height of the Revetments ~~are~~ is 10 feet.- At Simra and Pulra where the depth of canal water is 8 feet the height of these Revetments is 9 feet only.-

By

By adding to the above mentioned heights the amount of drop on each Lock, the depth of gate in the lower Chamber may be estimated. The following Table will shew this in detail. -

	Upper Chamber		Lower Chamber	
	Height of Revetment	Height of Gate	Height of Revetment	Height of Gate
	Feet	Feet	Feet	Feet
1. From Assoffnuggur to Sabli inclusive	11	10	20	19
2. From Savli to Dasna inclusive	10	9	19	18
3. From Pulra to Sirsa, inclusive	9	8	18	17

With the above exception the works as far as Lockage are concerned are identical.

At the No 2 and No 3 Locks in the Khadir, I have terminated the flank Revetments on the upstream side by Sweeps into the bank. In those which I am now describing, these Revetments are prolonged up-stream; that one on the right forming the front to a series of Inlets to Corn Mills; that on the left terminating in a Rajbuha Head. The design will be best understood by reference to Plate XXIX of the Atlas, I have, however, for the present restricted the number of mills (the Punchukki of these Provinces) to four for which 2 houses are built; the Revetment is of a length however sufficient to admit of a third house adapted to the same number of Punchukkies, for which all necessary arrangements have been made, by lining out the dimensions on an uniform scale with the basement fronts of the houses, and by building Inlets for the Mill Shoots, which for the time being are filled with brick work. The Inlets of these Mills

leave

leave the Channel on the high levels, the water being retained for the purpose by the regulating Shutter at the head of the waste Channel.- The tail or escape water passes away on the lower levels.-

This waste Channel is con-=verted into a receptacle for the sur-=plus water that falls on the Island and in the neighbourhood of the Mills the water is received into a well and passes into the Chamber by an underground Channel on the same plan as has been universally adopted in the Ganges Canal works

In occasional instances where the Inlet drain above mentioned is insufficient to relieve the Island from rain water another work on the same plan has been constructed on the down Stream side of the Locks as shewn in the diagram at S, in this case the front towards the water is covered by a flight of Steps

The excavated Channel is on the same plan and of the same capacity as that described in the Khadir of which a Section is figured in Diagram CXX .. The left bank forms the road, and Plantations as are described elsewhere.- The details of Earthwork with 2 ex-=ceptions which I shall describe presently are as a general rule precisely the same as those on the main Canal.-

In the whole of these works a perfect uniformity of design has been attempted. With regard to height of gates there are three distinct series as shewn by the above Table; in other respects, every dimension in one work is identical with that of the other. and conse-=quently the fittings which are

adapted

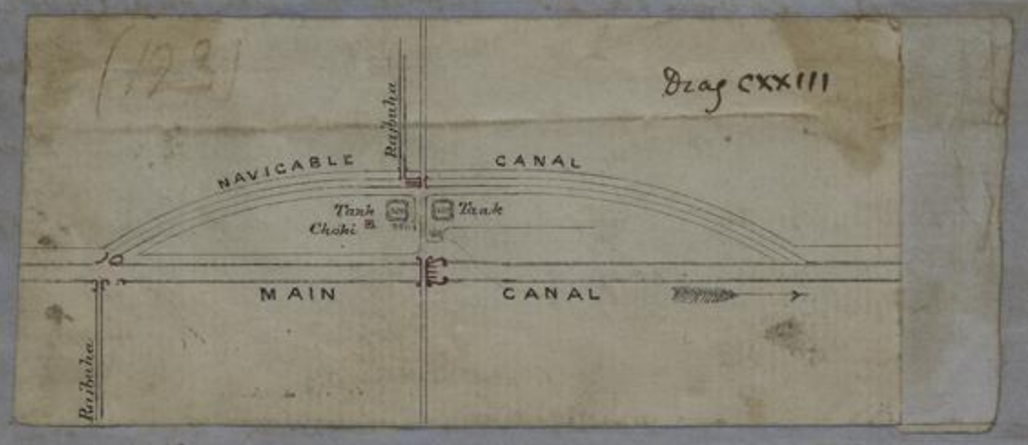
adapted to one are adapted to all
The advantages both to the supervisors
and to the works themselves of an
economical arrangement of this
sort are too well known to be dwelt
upon with any extraordinary
emphasis, they have, at any rate been
attempted to be carried out in all the
designs of the Ganges Canal
works, where varieties of dimension
have been reduced to the smallest
possible limits consistent with
efficiency.

Allen

The two exceptions to the uni-
=formity of detail in the Earth-
=work before referred to, are confined
to the navigable cuts at Muhmoodpoor
and Bhiola.

At Muhmoodpoor the alignme
=ment has been retained in all its
integrity, but in effecting this the
Channel came in contact with
a good deal of low ground, a jheel
or hollow of some extent was in-
=tersected, and for a considerable
distance the true level of the bed
was above that of the surface.
It became necessary, therefore, to
Embank that part of the Channel
which was connected with the low
ground, and to make such ar-
=rangements for procuring earth
for that purpose as would lead
to the least disfigurement to the
land in the neighborhood. The
following diagram will shew
the disposition of the works at
Muhmoodpoor, the site of the
Tanks or Reservoirs from which the
Earth has been taken to form the
Embankments, and the abnormal
position of the 1st Class Clothi de
=pendent on the irregularity of
the ground and the island formed
by

by the navigable cut.—

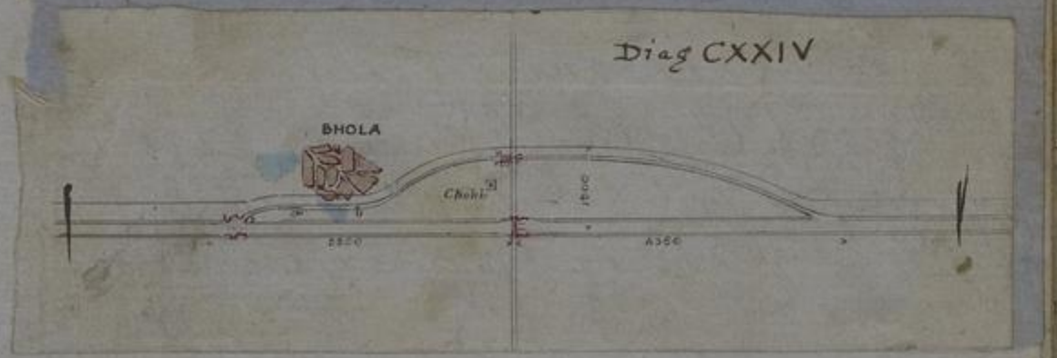


I consider that these Reservoirs are a nuisance; they have been retained within the smallest possible limits, on measurement calculated on the required demand for earth; they have been dug as deeply as economy would admit of, so as to reduce as much as possible an area which will necessarily become a field of reeds and water rushes:- and every thing has been done to render this nuisance as innocuous as it possibly could be - I am not without hopes that occasion may be found hereafter for filling in these Reservoirs should their existence materially affect the health of the station; this may demand a summary remedy, but it is possible that the clearance of the navigable Channel from silt and sand deposits may in the course of time provide material in sufficient abundance, for disposing of the evil with out any specific estimate. — necessity for

At Bhola, the variations from the general design are dependant on the village, which is situated within a short distance from the Canal boundary - It would have been necessary either to enclose the village in the island, by carrying the navigable Canal round

round it, or by making certain modifications in the alignement to keep clear of the village altogether. To have brought the village within the boundaries of the Canal would have been as annoying to ourselves, as it would have been inconvenient to the Inhabitants; we should not even by doing this have maintained the alignement in the required form; the Navigable cut would have been carried on a very extended circuit to meet the requirements of both parties, and laying aside the additional expense, the advantages appeared to be in favor of the modified course in which the village would meet with no interference. The plan therefore of the Bhola navigable Cut has been laid out as represented in the following Diagram.—

Diag: CXXIV



From a to b, the Channel has been widened out into a harbour for boats, which is a convenient appendage to the navigation; and the Earth which has been excavated from it has enabled us to equalize the surface of the ground in its neighborhood, and to complete the Embankments of the main Canal which would otherwise have been imperfect

In the construction of the Masonry appended to the works on the

the Navigable lines which I have thus described, bricks have been invariably used, with some trifling exceptions in the foundations at Tulawar, Bhola ~~and~~ Dasna Pulgra & Simra where the proximity of Kunkur Quarries has enabled us to adapt that material to the more massive parts of the Structure. At the above places ~~Pulgra excepted~~, the tail foundation walls have been laid upon blocks sunk to a depth of 12 feet, a necessity arising from the surface of Spring water shewing itself within the limits of the projected foundations. With the exception to the ~~foregoing~~ instances above mentioned, the works have been laid in dry soil, and have been constructed without any difficulty. The works at Chitonra have been built entirely of Small bricks, procured from the ruins of a large Serai which was purchased in the neighbourhood.

The above includes the whole of the works which have up to the present time been built for the purpose of Navigation, with the exception of those at the Terminus of the Cawnpoor Line which will be the subject of a separate Chapter. My Estimate of 1830 includes three works of this description which have been designed for overcoming the changes of level on the Cawnpoor and Etawah Terminal Lines; it is anticipated, however, that the smallness of these changes of Level will in all probability lead to a self adjustment by a natural equalization of Slope arising from the deposition of Silt and Sand ~~deposits~~, without any necessity for the introduction of separate works for Navigation. The terminal

Locks

Locks into the Irumna on the Etawah Line will agreeably to the present plan be postponed, until the progress of the works is farther advanced, or until the disposition of the Canal supply is fairly understood. These works are proposed to be similar in every respect to those which are now under construction at Cawnpoor, with the omission of those parts of the design which are expressly adapted to that particular locality. The Etawah Terminal works will be restricted to a Series of Locks on the Cawnpoor plan, the total amount of descent from the upper to the lower levels being equally distributed in drops of an uniform perpendicular height. These Locks will be connected by plain revetments and be accompanied by the necessary buildings and reservoirs, for navigation as well as for mill purposes.

6 Dawson

The Main Canal and its Branches are, it will be understood from the description formerly given, fitted on their whole extent with Towing paths for the convenience of passage; these paths are maintained uninterruptedly from one end of the Canal to the other, either by pathways carried under the Bridge Waterway Arches, or more commonly by passages in prolongation of the Towing paths themselves made under the bridge roadways. In the former case the boats proceed in their progress without any hindrance from the interposition of Bridges; in the latter, the separation of the Towing rope from the Cattle on arrival at a Bridge is indispensable. The plan which I propose to adopt is shewn in the

Diagram CXXV

~~the Vignette at the foot of this chapter~~, where it will be seen that one of the Bitt heads connected with the Rajbaha Channel above Bridge, acts as the support for a chain with a buoy attached, the buoy floating below bridge. On the arival of boats at the buoy, they are hooked ~~themselves~~ to it, whilst the Cattle and towing apparatus pass onwards through the passage; the boat people then either pull themselves onwards by means of the chain attached to the buoy, and then refix the boats to the towing ropes: or should the boats be too heavy for this purpose, the Towing rope is thrown to them from above bridge, belayed, and the towing upwards continues without the aid of the Buoy chain. Facilities are thus given for the passage of craft both up and downstream along the whole of the Channels connected with the Ganges Canal works.—

It is hardly necessary to descend on the value that will be derived to the Inland country especially, from the means of water Carriage provided by the Ganges Canal and its branches. Admitting that as a work specifically for Irrigation, the Canal will be liable during drought, to a want of supply at its lower extremities, and to occasional interruptions elsewhere; it will place the Central Districts and the numerous Towns and villages which lie on its course, in immediate connection with Mountain and Hill produce; it will introduce a new species of commerce in the

Countries

country through which it runs, and provide a supply of material for building purposes, which at present is unknown* Timber of all descriptions, rope, string, firewood, Charcoal, and the numerous articles of mountain produce which are now from the cost of land carriage shut out from the country markets, will by means of this inland navigation be freely circulated - The above are some of the first, simplest and most readily to be accomplished benefits that the Canal will confer upon the Country in its subordinate character of a navigable line - We may look, however to the higher advantages bestowed upon Countries in general by the introduction of water carriage. The transmission of heavy goods; the circulation of country produce and the means of a cheap conveyance to the community; are all the necessary consequences of works of this nature. -

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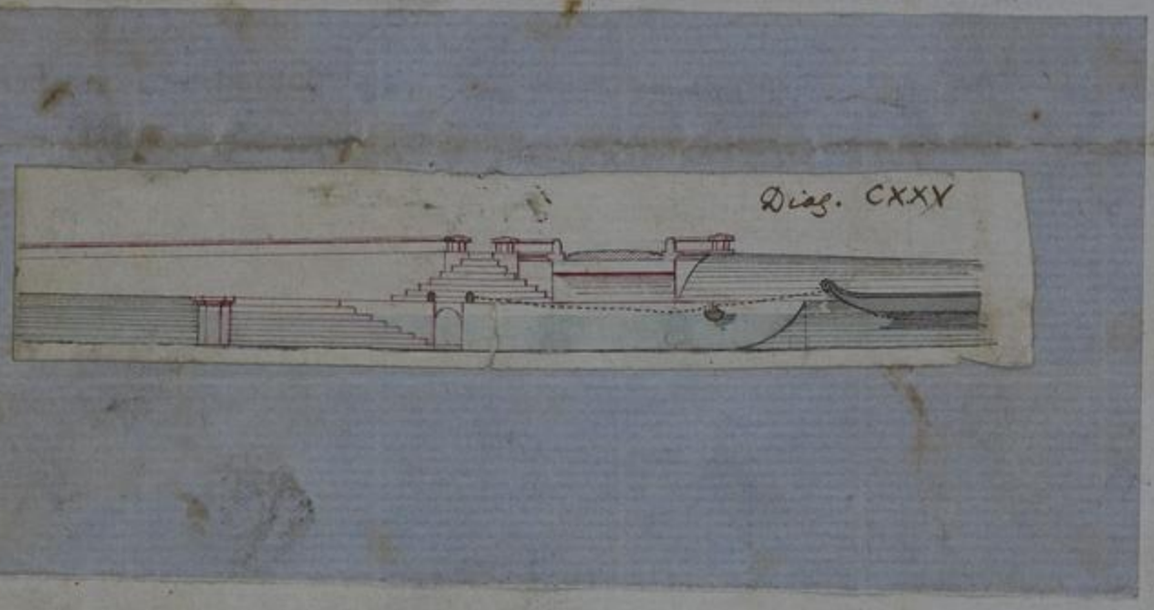
The total amount of Masonry and the Cost per 100 Cubic feet of the different works attached to the Locks and Navigation Cut Head works are shewn in the following Table The works at Ramboor and Puttri being omitted, as their Cost is included in that of the Superpassages under which Head it will be found. -

* In the central Districts of Myanpoor and Etawah the stalk of the castor oil plant is substituted for Bamboos and rafters in the Cottages of the poorer classes. -

Name of Work	Total Cubic content	Cost of masonry per 100 Cubic Feet			Cost of Stucco per 100 Sup.d Feet			Total Cost		
Bahadoorabad No. 2	83396	17	9	7	Included in masonry rate			15807	3	2
Do 3	81065	16	10	11	do			14701	5	2
Assoffnuggur	not complete	17	2	9	not completed			not completed		
Muhmoodpoor	127044	13	1	6	Included in masonry rate			23960	14	9
Bebra	126675	12	12	6	3	15	9	18109	14	10
Gaoli	131507	14	13	6	Included in masonry rate			21927	1	8
Chitowra	141537	11	6	9	3	13	9	18153	11	8
Sulawur	not complete	11	6	6	not complete			not complete		
Bholá	147444	14	12	10	Included in masonry rate			24174	13	2
Dasna	not complete	12	5	6	not complete			not complete		
Pubra	100480	10	..	4	2	7	7	12904	9	2
Simra	105443	10	..	.	2	7	5	13294	15	3

* The Total Cost shewn above is exclusive of Regulating apparatus—
The Bahadoorabad Locks have no Mills to them.



Diag. CXXV

CHAPTER, VI.

Works of Distribution

Section I. Rajbuha Channels and Earthwork

II. Rajbuha Heads and Masonry Work.

The whole of the design for these works, has been so fully entered into, in Part II Chapter IV, that I need say nothing further here, than that my object has been to avoid as far as possible any hasty proceedings in laying out the Rajbuhas until the Engineers could by being relieved from the heavy works on the main canals, turn their attention undivideably to the subject. I was moreover desirous that my Successor whose attention has been directed to Irrigation, and to the best methods adopted in Europe for distributing water for that purpose, should not be shackled or interfered with by any permanent works that might interupt his progress; it is with this view that although I have constructed all the Heads for Irrigation as connected with the main Channel of the Canal, I have made them of such a form, and of such a capacity of Channel, that they can at any time be fitted to the requirements of Modules or Machinery for regulating the supply of water. It would be a mere repetition were I to describe the position and detail of these works as a full ac-

=count has been given of them
in the Chapter above alluded to—

I have in the above Chapter
entered fully into my views as to
the general System of the disp.
=sition of leading and feeder Chan
=nels, and have shewn how com.
=pletely the tract of Country, which
we are called upon to irrigate is
commanded by the Reservoirs
of Supply.—

With the exception of the
Masonry Heads, the greater part of
which has been completed, nothing
further has been done in the Exca=
=vation of Rajbuha Channels,
excepting the laying out and
excavation of a portion of the
main lines on the right and left
of the Canal from the head of the
Assoffnuggur Falls downwards.
These were commenced early in
the rains of 1853, and were in
progress at the period of my in April 1854
assuming charge of the works.—
On the Right Side 40 Miles of
Channel had been completed; on
the left 36 Miles. Material in
considerable quantities had been
collected, and the Engineers were
only waiting for a relief from the
heavy works that were in progress
on the main line, to carry out
the Rajbuhas with vigor. For this
purpose a good deal of Surveying
and examination of ground was
in progress in the Meerut and
Bolundshuhur Districts under
the supervision of Mr P. Valle in
preparation for extending the main
lines in prolongation of Mr Read's
Channels which are now in progress
in the Saharunpoor, Muzuffurnuggur
and

and the upper part of the Meerut Districts

On the 1st Section, therefore, a mere commencement has been made, in the leading Channels from the head of the Irrigation on the high land of the Doab downwards. The work has been entirely done by Contractors, who excavate the Channel, and complete the Embankments at a rate of Rs 1.4.0 per 1000 Cubic feet. On the 2nd Section, which includes the Masonry heads, bridges, Aqueducts, Escapes, &c, the heads only have been completed to an extent corresponding with the progress of the Masonry works on the Main Trunk and the Terminal Lines from Narroon. This, however, includes the whole of the heads as far down as Narroon, as well as those on the Cawnpoor Terminal Line; those on the Etawah Terminal are finished or in progress as far down as the 110th Mile of the Course of the Channel.

None of the other works are commenced upon beyond the collection of Materials, and laying out the bridge and Aqueduct on the Khutowli Escape.

It will be understood from what has been said before, that the whole of the cost of the works connected with this Chapter appertains to the Zumeendars. They are in all respects Private undertakings, carefully laid out, and looked after by the Canal authorities, but no further chargeable to the Government, than in the advances

=vances of money made for their
construction - For further inform
=ation, however, on this and all
other points regarding works for
Irrigation, I must refer to Part
II Chapter IV. —

Asho

CHAPTER, VII.

Works for Machinery

The Heads under which this Chapter may be divided are

Section I. Workshops and Machinery attached.

II. Mills for Corn grinding

Section I. Workshops and Machinery attached.

Establishments for Workshop purposes were necessarily leading considerations in commencing the Ganges Canal works, and buildings for the accommodation of Smiths and Carpenters were amongst the first to which the attention of Officers was directed. The site of the Dam and Regulating Bridge where the Canal Channel leaves the bed of the Ganges River, is on the Estate of Myapoor, in which there is neither village nor population, the land being farmed by the people of Kunkhul, a town of considerable importance in the neighborhood. Close by the alignement of the Canal right boundary, a Serai or enclosure built partly of brick and partly of cut sandstone, with a pukka well near it, and at some distance an unfinished Mundul or Windoo building, were the only marks of habitable settlement: the former was used for cattle, the latter was deserted

deserted. The Serai which in its external measurement is 130 feet × 98·5 feet was readily made over by the Proprietors on an annual rent of 50 Rupees, and it was immediately converted into a work-shop. Its interior was conveniently adapted to the purpose; on two sides were covered rooms with verandas in front extending on the full width of the Quadrangle. On the other two were gateways, that on the north sufficient for the Entrance of men and cattle, and having some pretensions to architectural character, the other being 11 feet in width and capable of admitting carts. With the additions of rooms for forges &c. which were arranged on the flanks of the Entrance, this Enclosure became of the greatest use, and ~~up to the period of~~ while the Head Quarter Station remained at Nujafgur was the leading workshop. Since then it has been used as a Lock up Store room, and it may be considered as an useful appendage to the works in the neighbourhood.

As early as 1823 and shortly after the Munglour Division of the works had been established by Capt. Turnbull of the Engineers, the preparation of workshops on a more extended scale in the neighborhood of the Solani River, and near the Site of the Aqueduct, was undertaken. The Town of Roorkee ~~which is~~ situated on the edge of the high land which skirts the Khadir or low tract through which the Solani passes, was the

point

point on which the Aqueduct was directed; its neighborhood was marked by undulating ground with Knolls, many of which bore the marks of having been the Sites of ancient villages: these were Separated by Ravine hollows acting as drains or water courses from the higher to the lower levels The Spot which I Selected for the Roorkee workshops was on the highest of the Knolls above des-=cribed, and lying immediately on the left of the Canal on its reaching the Bangor or high land of the Doab. From the quantities of broken pots and Crockery with which the surface was covered, this Spot had been Evidently the Site of a former village, at some distance from it were the remains of Mussulman Tombs; it was well adapted to our purposes, and in its then uneven and irregular Surface was capable of giving accommo-=dation to an Enclosure of 250 feet Square. This Enclosure was completed previously to my proceeding to England in 1845. Independently of the mere enclosure the Quadrangle was provided in its interior with accommodation for Smiths and Carpenters, in lines of arcaded rooms extending on its whole length on the East and West sides. On the former, Offices of different descriptions, including an Instrument and Model Room were constructed on plans which accompanied the printed report of 1845. This Quadrangle and the

the accommodation above described served its time, and became the Nucleus of future buildings to meet the constantly increasing wants of the works. ~~During my absence from India from 1845 to 1848~~ During my absence from India from 1845 to 1848 I also the interior of the Quadrangle had received a further increase to its accommodation by the addition of arcaded rooms on the North and South similar to those which had been before built on the East and west Sides; ~~a extension of tank had been built in the Quadrangle~~ and there were clear and unmistakeable signs that the accommodation was entirely insufficient. At this period, moreover, the Earthwork on the Aqueduct had arrived at that point, when mere manual and basket labor had ceased, the Earth required for the enormous Embankments forming the line of Aqueduct was now to be brought from the sides of the valley, and from a distance which rendered railroads and Earthwagons indispensable; for these purposes it became necessary to extend our workshop accommodation, and at the same time to improve our means by the application of Machinery, and by the use of superior tools A design for additional workshops in extension of those already built was therefore submitted to the Government, who at the same time made an application to the Court of Directors, for the despatch from England of Machinery adapted to

to our particular requirements I had when in England secured the services of a practical Engineer who joined me in the Month of August 1848, and about the time when the alterations which I have above allluded to were about to be commenced. - Shortly before, or in the month of July 1848, Lieutenant Augustine Allen, an Officer in the 55th Regiment of Native Infantry, was appointed as an Assistant to the Executive Engineer of the Northern Division, for the special purpose of taking charge of the Workshops, the designation under which he was appointed being "Engineer of the Timber Yard" The Roorkee Workshops therefore began at this time to assume a more defined shape than they had done previously, and a system of order and method, with improved habits of conducting the Manufacture of Iron, and of carrying on the duties of the Timber yard began to exhibit themselves in a very marked degree. No great Step, however, could be made until the Machinery had arrived from England, and until the increased accommodation which this, as well as the increase of Workmen rendered necessary had been completed. The improvements and additions which were at this time made, consisted in Separating the Iron from the Timber Department, confining the former to the original Quadrangle, and making a new Enclosure in connection with it for the purpose of the Carpenters (In

In Plate LIX of the Atlas plans of these Shops are given in the fullest detail) This new enclosure which is a mere extension of the former one extends as far South as the high road of approach to the Rookee Bridge; it occupies ground which previously had been a great disfigurement from its irregularity of Surface. The filling in of the extensive hollows attending upon this irregularity, enabled us to smooth off and level the whole of the ground on the East face of the Quadrangle and fronting the Model Rooms; and the construction of the Enclosure in addition to giving Space to the workshops, was one of the greatest possible improvements to a Site which must otherwise have been not only ugly, but offensive from the usual causes, which in the vicinity of Native Villages, ~~renders~~ affect injuriously all ground of this sort ~~offensive~~. This Enclosure which is confined in its strictest sense to Timber Works, consists like that of the Quadrangle before described of an open central area, surrounded by Shops and Warehouses resting upon the Encircling wall; the Shops are arcaded in open lines for the use of the Carpenters; the Warehouses differ merely in respect of their being fitted with doors and means for the protection of property.

Hull. It will be understood from the position of the Quadrangle or Iron Yard, situated as it is on a high mound, that it

it is much Elevated above the Canal, which passes close by and parallel to it. Sufficient distance having been left between them to admit of an extension to the buildings on that face. Here therefore or on the western side of the old Enclosure of 1823, very extensive accommodation, in the shape of Lathe rooms &c has been built. The higher portion of the ground or that on a level with the existing buildings being occupied by Engine Lathes and Machinery; that on the lower which constitutes a basement (with an upper story) being devoted to furnace and boilers with the Sawing Machinery, the upper story which lies on the same level with the Lathe room being occupied by the finer sort of Smiths and Carpenters work. The Façade formed by the above mass of building is in prolongation of the western wall of the Timber Yard Enclosure, and at a distance of 40 feet from the steps or Ghats which line the Aqueduct; here it was intended to establish Quays and Cranes in communication with the Workshop yard. On the Eastern face of the Iron yard or Quadrangle and directly opposite to the buildings above described, the Model Department which, as originally built, consisted of one room of 40' × 20', has been increased by the addition of a room of equal dimensions placed parallel and connected with it by a wide aperture supported on

on each side by plain Doric pillars, isolated, and flanking circular headed niches formed in the wall. - This large room is furnished with Tables made of Stone slabs, and is devoted entirely to Models, to Library which occupies deep recesses placed in uniform positions in the room, and to Pictures of either Public works of great Interest, or of Men who have distinguished themselves in connection with them. This addition to the Old Model room led to a projection equal in extent to the size of the new building, in front of the original Facade. this projection has been covered by a Veranda or Colonnade corresponding in character with that of the original work; its centre being occupied by a Clock Tower, the basement or lower Story of which acts as an entrance hall or vestibule to the Model rooms

The building of the above works extended through some years in so far that additions and improvements adapted to circumstances were constantly in progress; in 1849, however, the most necessary portion, including the Lathe, Model and Engine accommodation was entirely completed, and in 1851 the Machinery which had been ordered and sent out by the Court of Directors arrived at Roorkee. This consisted of the following. -

1 - 10 HP condensing Steam Engine with Boilers -

1

1 Large planning machine
1 Drilling and boring Do
1 Small Drilling Do
1 Punching and Sheaning Do
1 Lathe . 12 foot
1 Screw cutting Lathe 8 foot
1 Do Do 7 in
1 Steam Jinn
1 Screwing Machine
1 Blowing Fan
2 Grind Stones
Saw Machinery
1 Baulk Frame
1 Deal Do
1 3' Circular Saw
1 2' Do

No time was lost by Lieut Allen aided by Mr Murdoch the Practical Engineer in fixing the Machinery, and in the month of May 1852, the greater part of it was at work; ~~for~~ the delay that took place we are by no means responsible. By some mistake or other, the Steam Engine which was sent out was ... adapted to boilers placed on the opposite side to which the buildings for them had been designed; it was therefore necessary to change the direction of the steam pipes, the work for which could be done at no place nearer than Calcutta, this was a great loss of time, although it was economized in a great measure, by completing in the interim the different arrangements in the Machinery room. The Shafting attached to the Saw Machinery consisting of most unnecessary changes of motion, and complicated by these changes to a somewhat unaccountable degree, was con-
demned

demned and a simple and direct
Shaft was substituted. ~~These with~~
A number of minor objections ~~has~~
were raised ~~to parts of the Machinery~~,
all of which had to be corrected, and
~~portions of the machinery itself~~ ~~many of them~~ from their weakness
had to be strengthened, ~~occupied~~ occapied whereby time was necessarily
~~time~~; ~~which taking everything~~
~~into consideration was about to~~ however
~~comparison to the changes and~~
~~alterations that had to be effected~~.
The Steam Engine, ~~however~~, was
a serviceable one, and the Machinery
although not of the best, being as the
Practical Engineer remarked "made
"for Exportation to the Colonies" has
been working ever since tolerably
smoothly -

In addition to the Machin-
-ery above mentioned, Mr Murdoch the Practical
Engineer ~~who had accompanied~~
~~me from England~~, set up a small
2 Horse power Engine which I had
2
many years before purchased ~~from~~
~~an Amateur who had got it out~~
~~from England as a Model~~. This
~~little Engine~~ with a new boiler
(that I had brought from England
for the purpose) was up to the
period of the large Engine being
fixed very usefully employed,
in turning 2 Lathes, a grind
Stone, and a punkah which worked
over the heads of the men at the
lathes. ~~This little Engine~~, being
high pressure, and in all probability
made 20 years ago, this Engine was rather
complicated in its parts; it was
much worn and injured, and
since the removal of the lathes
to the room constructed especially
for their use, has been laid aside -

The

The Lathes which were turned by the little Engine were brought out by me from Holtzapffels from whom the following articles were received at Roorkee, almost simultaneously with the arival of Mr Murdoch the practical Engineer, under whom they had been selected.-

1 Self acting Lathe, entirely of Iron 8 Inches Centre - for turning work 6 feet long.-
1. 5 Inch Centre Lathe
(130th Lathes being complete in all respects for every variety of work)

Tools of various descriptions.-

besides the above the following Machines had been purchased for the use of the Shops.-

1. 5 Inch Foot Lathe by Holtzapffel
1. 5 Inch Do Self acting and Screw cutting by Whitworth
1. 5 Inch Do Do
1. 5 Inch Self acting Foot Lathe by Whitworth
1 Small 5 Inch foot Lathe with common T rest
1. 7 Inch Lathe

So that on the arival of the greater batch of Machinery from the Court of Directors the Shops were very fairly supplied with the means for carrying on any work that they were likely to be called upon to perform-

During the whole of the period above mentioned, and from the date of Lieut Allen's joining the workshops, his attention had been most energetically directed to the Manufacture of Tools, with which

which previously the Shops had been totally unprovided; he had also prepared a variety of useful machines for simplifying work amongst which I may enumerate the following.-

Steam Hammer
Suppliers Bolt screwing tools for hand and Machine Screwing.
Punching Machine
Drilling Do
Key grooving do
Pumping Engine for supplying the premises with water -
Foundry Tools. ~~many experiments with plaid and Material to be found in the Neighbourhood~~

and he had introduced amongst the native workmen a variety of improvements not amongst the least important being the banishment of the excessive use of the File, and the substitution of Chiselling. A great deal of useful practical improvements had also been introduced into the system of Forging iron, and into economy of fuel. The fuel used is entirely Charcoal, and the forges previously to the introduction of the blowing apparatus, were worked by Large bellows with hand levers, excepting in cases when the native forge was employed, where the blast is gained by leather bags to which a nozzle is applied. These forges were entirely remodelled and without pulling down the building in which

which they were placed, they were by a judicious disposition brought in direct contact with the blast from the blowing machine, the adaptation of which to the Steam Engine was greatly improved by Lieutt Allen, who as in the case of the Saw machinery, changed a complication of Shafts into a simple bearing on the mainaxle This new arrangement of the forges gave additional room for working, improved the ventilation of the low arcaded rooms in which they are situated, and greatly economized Space. The whole of the improvements that were made in connection with the setting up of the Machinery, and with the reorganization of the Material depending upon it, appeared to me to be very satisfactory.

Alder

During the above period ~~this~~, a brass foundry on a Small scale had been established; a weighing apparatus similar to that which is so frequently used at English Turnpikes where the value of the load is read off in a Side room, had been attached to the floor of the main Gateway through which loaded carts entered A Department of painters for the purpose of graduating levelling rods &c. had been organized and Saddle and Harness makers carried on a very successful trade in making Harness of descriptions, Shoulder Straps for the barrow men, together with the whole of the Leatherwork required on an extensive board of

works

Works.—

The Shops up to the year 1831 were employed entirely on the manufacture of articles required for the Ganges Canal works which kept them fully occupied, boats both of wood and Iron had been made for the use of a navigable Canal which since 1818 had been in constant use for the purpose of transporting boulders and building material from Myapoor and the branch of the Ganges in its vicinity, to the Ranipoor and Bahadoorabad works; numbers of Earth wagons had been made for the use of the Solani aqueduct Embankments, and for the supply of material from the Brick manufactories in the neighborhood; fixings for rails, and the Iron work necessary for keeping up this species of communication had been in constant progress.— The works at Dhunoura had also been supplied with both wagons and rails; and the numerous articles more especially in demand for Sluices of Dams, Regulating Bridges, and for all the Emergent wants of the works in progress had been carried on without interruption.—

Early in 1831, the demand for both Surveying and Mathematical Instruments, at the Roorkee Civil Engineers' College raised a question as to the advisability or not of taking advantage of the Roorkee workshops in forming in connection with it, a Department for their manufacture and repair: the extensive works in the North West Provinces,

and

and the demand that these works occasioned for Instruments of all descriptions appeared to point out the Roorkee College as an Institution in which a Depot of Instruments might be well main=tained for the purpose of distri=bution. Roorkee with its Civil Engineers College, Workshops, Model Department, and in the immediate neighborhood of the most interest=ing portion of the Ganges Canal works, appeared to be in many ways more appropriate to the purpose of depot, than the differ=ent Ordnance Magazines scat=tered over the Country; whilst for repair, it was beyond all question more convenient than Calcutta.-

It was proposed, therefore, that the Mathematical and Sci==entific Instruments now in deposit in the different Magazines should be collected into a well regulated depot at Roorkee; that a stock of the best Instruments of all kinds commonly required, be maintained by regular supplies from England, and that these should be held for sale, or for loan on the Public Service under rules drawn up for the purpose and promulgated for general inform=ation.-

It was further proposed that there should be a workshop in connection with the Depot for the repair of Instruments procured from England and for the manu=facture of such as can be made in this country.—

The plan was seconded by

by the following strong recommend-
-ations, 1st The great demand that
existed for such Instruments in the
North West Provinces and the Punjab.
2nd, the insufficient provision for
their safe custody in the several
Arsenals, and the delay and risk
attending their transmission to
Calcutta, and it was approved of
with hardly a dissentient voice.

It was observed with regard
to the Establishment of this Depot
at Agra as the Head Quarter Station
of the North Western Provinces, instead
of at Roorkee, that the latter is
in the neighborhood of the great
works now in operation & con-
-struction on the Ganges Canal, and
that even when these are finished,
that as works of Civil Engineering they
will in all probability be the most
interesting and instructive of any
to be found in India. That a large
body of Scientific Officers are there
assembled, with Skilful artizans,
well seasoned materials and power-
-ful Machinery for working up
these materials: that, moreover, at
Roorkee, there is a large and in-
-creasing Collegiate Establishment,
the Pupils of which it is of much
importance to render familiar
with every thing that concerns the
Instruments with which they will
have to work. - Agra, although the
Metropolis of the North West Pro-
-vinces, and the seat of the Civil
Government, has none of these advan-
-tages, it does not even contain a
Superintending Engineer, or any
Scientific Officer, excepting the
Executive Engineer of the Division-

Roorkee V

Rookee it was maintained had on the contrary the greatest facilities for carrying out the Project.. Lieut. Allen of the 55th N. I. in charge of the workshops was peculiarly skilful in making and repairing Instruments and in training up natives to execute such work. Lieut. Allen had already done much in this way and his presence at Roor-kee had obviated the necessity of incurring the otherwise unavoid-able expense of bringing out from England a Mathematical Instru-ment Maker. Much had been done even at this time by Lieut. ~~Allen~~ in forwarding the progress of the manufacture of cheap and simple substitutes for such of the more expensive Instruments as could be made up easily in this country, and come within the means of native workmen. It was clearly desirable that the efforts which had been thus irre-gularly and desultorily put forth should be reduced to order, and systematically exerted.

The delay and annoyance that had been experienced in the adjustment of the Steam Engine, in consequence of our inability to obtain a casting, so as to direct the steam pipe upon the boilers, and to remedy the defect of the machinery as received from the maker; brought prominently to my notice the necessity that existed for making an Iron Foundry a portion of the workshops. The case alluded to is worthy of record-ing, as an example of how a trif-fling mistake in the 1st instance may

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may affect the receivers, who so frequently are entirely cut off from the means of remedying it. - In the present case the Steam pipe which ought to have had its bearing upon the boilers which were placed on the left of the Steam Engine, had it on the right, so that without an alteration of the direction of the pipe on its leaving the Cylinder, the machine was useless, unless the building had been remodelled to adapt itself to the Engine. - All that was required was a short bit of pipe with a bend or shoulder in it, which had a Foundry been present we might have made in a few days; here, on the contrary, although no time was lost in writing and sending drawings to Calcutta, we did not receive the article required until a period of 4 months had passed. We had in fact to send to a distance of 1000 Miles to get a thing that might with ease have been made at Roorkee had a Foundry been present. This although the first and leading inconvenience was only one out of a great many which gradually shewed themselves as the workshops advanced. In a letter which at this period I addressed to the Military Board, it is observed in drawing attention to the above circumstances "I am by no means anticipating the wants of even our existing works in suggesting that no time should be lost, in establishing an Iron Foundry at Roorkee; we require the presence of a man who is acquainted with

with the Art, but beyond this, and the construction of the necessary buildings, I do not imagine that the addition of the Foundry to the Yard would lead to any extraordinary expense, whilst it would give us the means of supplying ourselves at once with articles which we now at a great cost of time and carriage have to procure either from England or Calcutta, and in a late instance instead of being able at once to sup=ply ourselves with a portion of Steam pipe, we have been forced to send a commission for its man=ufacture to a Foundry situated at a distance of 1032 Miles from Roorkee. With reference however to the higher advantages and to the more general application of these workshops to the supply of the Provinces with Iron work whether forged or cast, it strikes me that the sooner ~~that~~ the Foundry ar=rangements are entered upon the better. the whole of the Provinces might in my opinion, and ought to be supplied with Iron bridges, Roofs, Castings, &c^a from Roorkee, and whilst Calcutta is the cen=trical point for the Lower Provinces and Bengal proper; Roorkee would be more centrically, as well as more conveniently situated for the Provinces in the North. In conclusion I may observe that even with reference to the cost of English Iron as far North as Delhi, and the fact that we can at present procure that material at Roorkee at a cheaper rate than we can native Iron from Gwalior; I am by no means satisfied that in the extensive distribution

distribution of Iron Mines throughout the Mountains in immediate approximation to Roorkee, we may not through a well appointed agency open out an entirely new Market for Iron, and turn to useful account one of the neglected ores of the Himalaya Mountains".

The Establishment of Workshops and Foundry at Roorkee, a place which was situated within 15 Miles of the Sewaliks, and 40 Miles of the Himalayas, would it was supposed bring into activity any dormant claims that the Mines in the Himalayas might have upon the attention of Metallurgists. With forests to supply Charcoal, and mines to supply Iron, the Roorkee Foundry would be independent in its own resources, whilst the clays and earth which abound especially in the Sewalik Mountains, would be a fruitful field of interest in the Manufacture of Pottery.

The whole of the above views were adopted by the Authorities without any demur~~rer~~, and having ultimately been approved of by the Court of Directors they were ordered to be carried out as early as possible. The delay that has occurred in promptly acting on instructions which were asked for with such eagerness, arises from the great extent of the works both on the Canal and College, which has up to the present period, absorbed every brick as well as every Laborer that could be collected together; from this

this cause the extension of buildings necessary for the Foundry and other purposes has been most unwillingly placed in abeyance, at least so far, that the new buildings have only been carried on as material and opportunity offered. The designs however, have been well matured, and progress although slow, has not been altogether stopped. —

Correspondence

The correspondence on the subject of this extension of the work-shops which commenced in July 1850, and which had closed in the approval of the Court of Directors to the whole of the schemes which had been recommended, led to the following arrangements, which may be best explained in the words of a minute dated the 18th December 1851, and submitted by me on the closing of the correspondence.

"1." As introductory to the following memorandum it may be better to explain the views which I hold as to the Mathematical Instrument Department as connected with the General workshops at Roorkee. I believe that these views are the same as those explained in Mr Secretary Thornton's letter to the Military Board No 398 A of 1850 dated the 29th July 1850, on this subject, but as the whole of the scheme depends upon a proper understanding of the wishes of the Government on this point, it is as well to explain my reading of them.

"2 The Civil Engineer's College at Roorkee is to be the Depot for serviceable Instruments, Astronomical, Topographical

Topographical Meteorological, and Mathematical - It is to be under the control of the principal of the College for the time being -

"3 - All Instruments the property of Government now deposited in Store in the Magazines or elsewhere, are to be transferred to this depôt and a supply of those in most common demand is to be maintained, not only for the use of those employed on the Public Service, who will obtain them under certain regulations to be hereafter defined, but for the public generally; Instruments being held available for sale for ordinary scientific operations, and for the equipment of individuals whether publicly or privately organized for scientific purposes - The prices are to be regulated by the actual cost upon the office books - Barometers and other Instruments for Meteorological purposes, which are now obtained with such difficulty, and for the want of which so much valuable information has been lost, will by these means be always available; at a place, moreover, so conveniently situated to the Himalayas and to the most interesting portions of our Indian Territories, as to render a facility for procuring Instruments of the sort referred to especially valuable. -

"4 - The Mathematical Department of the Roorkee Workshops will be confined entirely to the Manufacturing and repairing of Instruments for ultimate deposit in the Depôt - All Instruments received from the Magazines or elsewhere will

will pass through this Department previously to their being lodged in the Depot. Its control will be vested in the Superintendent of the workshops, whose transac-tions with the Principal of the Civil Engineers College as the Of-ficer in charge of the Depot, will be conducted in the usual official form of correspondence and record.

"5. It is understood that by keep-ing the "Depot" and "Department "of Manufacture and repair" dis-tinct, and under the management of Officers independent of each other, the Instruments will undergo sepa-rate scrutinies both in workman-ship and adjustment, both of them tending to insure the great object of maintaining a supply of efficient and Standard Instru-ments ready for immediate use.

"6. The College, therefore, being understood to be the "Depot" and the workshops the school of repair and Manufacture. I now proceed to the subject of this Memorandum viz: the Institution of the Roorkee workshops.

"7. The workshops at Roorkee would under a comprehensive plan for making them generally useful in the North Western Provinces con-sist of the following Departments

1st Iron and Wood for General purposes
2nd Mathematical Instruments
3. Foundry.

"8. I would place the whole under charge of One Individual, called the "Superintendent of the "Roorkee Workshops" his salary would be 500 Rupees per month with

with an Office Establishment - As an Executive Officer he would open an account with the Accountant General North West Provinces, and his duties would be carried on under the direction of the Director of the Ganges Canal works and the Superintendent of Canals N.W.P.s. It is indispensable that the Executive Engineer in charge of the works in the Northern Division of the Ganges Canal should have unlimited power in procuring the aid of these workshops, and that calls from the Executive Engineer should be attended to in preference to all others; should this not be admitted or not carried out to its fullest extent, the Executive Engineer must necessarily fall back upon his own resources and Establish independent workshops for his own supply.-

1.- Iron and Wood for General purposes

" This Department would consist of the present Iron and Timber Yards, in which Iron work for roofs and Suspension bridges &c., Timber work of all descriptions required in the Department of Public works, and the general Manufacture of all articles of both Iron and wood required in the different departments of the Service would be undertaken.-

"10. The Iron Yard would contain warehouses for the maintenance of a Depôt of Hardware, such as Tools, Locks, Keys, Hinges, Nails and other articles used in the Department of the Public works. I would not restrict the sale of these

these articles to the Public Depart-
-ments of Government although
these Departments as a general
rule, and when there was a de-
-ficiency in store, should have
the preference. One great object
that I would have in view would
be to hold out to the people of the
Country a supply of wares of a
superior description to those made
by themselves: to introduce amongst
them at prices which would be
remunerative, Tools of a superior
description; and to put them in
the way of not only (by inspection
of the Shops) observing the
European method of working, and
judging of its superiority or other-
-wise over their own; but of possess-
-ing by purchase the means of
imitating us, and advancing in
a parallel course of improvement
In illustration of this object, I may
mention that a large supply of
handsaws, which were procured
from England for the purpose above
mentioned, has been disposed of,
and Articles of a similar description
are in eager demand by the
native Carpenters. I would also
observe, that the distribution of
Stores of this description would
keep up a healthy circulation in
the Depôt; it would prevent that
accumulation of old and obsolete
material, which I am given to un-
-derstand exists to a great extent
in the Magazines of this Presiden-
-cy, and which in the shape of
the very articles which I allude
to above, did exist up to a very
late period in the Warehouse of
the Executive Engineer of the Cawnpore
Division

Division of Public works. In the case of the Magazine Stores, public sales at distant prices relieve the warehouses from lumber and refuse material, but at an enormous sacrifice to the State, whereas had the articles not required been disposed of from time to time by Private Sale, the objects to which I have above alluded, and on the advantage of which I place so much weight, would for a long series of years have been in steady progress.

"11. The Military Board in their letter to the Agra Government No 3700 of the 5th August 1831, have in pointing out that all the Kentledge now lying in the Magazines might be advantageously collected at Roorkee; gone very far in approving of the Roorkee Shops becoming the Centrical Depot of Store and Supply; and it strikes me that with the exception of Articles strictly appertaining to the Military and Artillery branches of the Service everything now in those Magazines lying within a reasonable distance might with advantage be sent to Roorkee; which as a Civil board of works connected essentially with Education and established for the purposes of supply and distribution would turn to better account the Stores now in course of receipt on Indent, and would be better able to dispose economically of the old Stores, than were they sold by public auction at the periodical Magazine Sales.

"12. The "Timber Yard" would in the same way act as a Depot of

Wilkinson

for wood of all descriptions, es-
=pecially Sal (Shorea Robusta)
and the proximity of Roorkee to
the Sewalik Forests, as well as to
the Himalayas, would extend
the benefits of this yard as a
wood depôt, by enabling the
Superintendent to keep up a
supply of many useful Mill
articles, especially woods which
are at present little known and
their value (from the difficulty of
obtaining them, and in many
cases from the ignorance of their
existence) less appreciated. A
true Box (Buxus Emarginatus)
is easily procurable from the
neighborhood of Landour; it
appears to be of excellent quality
and is likely to be serviceable to
the Wood Engraving Department
of the College. Both Sal and
Turpentine from the Pinus Longi
=folia (Cheer) of the Sewaliks (during
my Superintendency of the Eastern
Jumna Canal a Sal manufactory
was constantly at work under
my direction at the Kalowala
pass of the Sewalik Mountains)
are to be made with the greatest
ease, and, as unadulterated are
more likely to offer a better and
a cheaper supply than those
imported for the Magazines.
Cordage Materials, Resins,
Dyes and an infinity of Materials
useful in both arts and manu-
=factures, might be brought into
general circulation through the
medium of this Depôt.

9/3. The connection between
the Ganges River at Hurdwar, and
the workshops by the Ganges Canal

would by giving the means of
floating down Rafts of Timber
enable the Depot to be supplied
with a variety of woods from the
interior of the Himalayas. Deodar
Ash, Walnut, and woods indig-
-enous to the Temprate climate
of the Interior might by these
means be collected at Roorkee,
By an economical distribution
of Time and Labor also, these
rafts might carry supplies of
Cordage Material, and I have
no doubt that at a very early
Period, a correspondence having
been established between Roorkee
and distant points in the
Himalayas, numerous products
would come to light which at
present are unknown - I might
here allude to the great variety
of clays, many of them I have
no doubt available ~~for~~ for Pottery
and ~~for~~ for other uses, which exist
in the Siwaliks, and in their
neighborhood, and to the ad-
-vantages that we should derive
from the presence of an Officer
with the talents and energy of
Dr. Alexander Hunter of the
Madras Medical Service, whose
researches in the natural resources
of his own Presidency, in doing
honor to himself, and to all whom
his example has carried with him,
ought to stimulate us not to
be behind hand in a field, I have
no hesitation in saying, of equal
if not greater importance, than
any in the British Possessions of
India. - To carry this subject fur-
-ther would be foreign to the object
of this paper but the Industrial
Exhibition

Exhibition and Dr. Royle's pamphlet on the proposed contributions from India will to all who are interested in rescuing the natural products of a large extent of country from their present obscurity, shew what an active agent the Roorkee workshops may become, in not only doing this good work towards the Himalaya, but also to the Provinces of Upper India.—

II. Mathematical Department

"15. It having been decided that the Depot for Surveying and Mathematical Instruments should be attached to the College, and that the manufacture and repair should be a separate Department of the Roorkee workshops, we have merely to take into consideration the best means in carrying out the latter object

"16. This object has been described in the Honorable the Lieutenant Governor's minute dated the 21st May 1850 as follows:—

1st The manufacture of Instruments in common use, and generally made up in this country Levelling Staves; Prambulators; Chains; Plane Tables, Tripod Stands &c. The invention and formation of cheap substitutes for expensive machinery: e.g. Common Carpenters might make up plane Tables, Quadrants and Levelling Instruments, which would enable an ingenious man to observe with a considerable approach to accuracy both Horizontal and vertical angles: Water or T Levels for levelling; giving a large scope for

for ingenuity in popularizing the
Materials for scientific research.-
2nds The repair of Surveying and
Mathematical Instruments.-
"17- With ~~a~~ reference to the 1st
Item, without discussing this
advantages that would be derived
from maintaining a depot of
Articles as enumerated above, both
by the Canal Officer and the Civil
Engineer; ~~the simple fact of readily~~ ~~I need hardly~~ sup-
-plying ~~the one~~ with Levelling staves
or the ~~other~~ with Chains would
~~gain~~ their ~~his~~ sympathy ~~with such an Es-~~
~~-tablishment~~. Levelling Staves
on Gravatt's plan of graduation
are now made by Lieut Allen
in a manner equal to any that
could be turned out of a London
Shop.- Chains are also made equally
well, and both these articles have
the advantage of being graduated
and compared with a Standard:
of the facility ~~The~~ for carrying out this
first object of His Honor's minute,
there can be no doubt whatever.-
"18.- The difficulties in which an
Officer is placed in these Provinces
from the want of the means of
having Instruments repaired
has been well pointed out by
Colonel Everest in the preface to
his last work on the Indian
Meridinal Arc.- Colonel Everest
has shewn, moreover, what can
be done by a man of skill and
intelligence, who when perfectly
acquainted with the construction
and value of the parts, finds him-
-self in the midst of a wilderness,
with an Instrument almost hope-
-lessly broken or disarranged by
~~accidental~~ circumstances to which
he

he is perpetually liable! The inductions are obvious; 1st that even the most complicated Astronomi=cal Instrument can be repaired even without the aid of the pro=fessional Craftsman; and 2nd ly that by an Institution similar to that now proposed, these pro=vinces remote as they may be from either the Metropolis of India or from the Mart and Manufactories of Europe, may hold within them=selves the means of not only re=pairing, but also of making Instruments.

Plumb

"19- The making of Instruments however, is a question upon which a few remarks may be necessary It is not presumed that the Mathematical Department of Roorkee will during the present period, or even for many years compete with Europe in making the more complicated apparatus attached to the Astronomers obs=ervatory, nor could it pretend even to a competition, with the Professed Mathematical Instrument Maker either in the best descriptions of Surveying Circles or in the In=struments attached to the Draw=ing Department. I believe that even were the Roorkee Shops pro=vided with efficient men, it would take some time before the compli=cated machinery necessary for the manufacture of Articles in large Quantities would enable them to compete with English prices, but to every one who is ac=quainted with the extraordinary patience of the native character,

the

the delicacy of Manipulatory touch which is the characteristic of our native workmen, and the great capacity (where intelligence is met with) for observation, with imitative powers of the highest order; will, if he admits the character to be correct, agree with me in appreciating the value of the material that we hold for progressive improvement, and without any great stretch of enthusiasm anticipate the period when we may not only be able to compete with Europe in the Quality but (from the Cheapness of native labor) undersell them in the prices of their Instruments. I consider that the present Engineer of the Shops is peculiarly qualified to carry out the objects of the Lieutenant Governors minute on this point, and if he is allowed the encouragement that I would propose to give him, the progressive advance which is alluded to above, will in all human probability be certain.

One of the first articles which would be necessary for the purpose of Instrument making, is a dividing apparatus, which might be procured from England, but should there be any difficulty thrown in the way I am satisfied, and in this I am borne out by others, that a short time only is required to make ourselves independent by our own exertions; it is very satisfactory to me to be able to place this opinion on record, but I do so in perfect confidence that I shall not be mistaken. The cost of an apparatus of the sort above mentioned may be I understand about 10000 ✓

10000 or 12000 Rupees.-

Additional and Separate ac-
-commodation will be required for
this Department, although such
arangements are proposed to be
made, as will insure compactness,
and place the Shops which are
Specifically for Mathematical
Instrument purposes, in immediate
connection with the general Shops.

Lieutenant Allen with whom
I have consulted, and who is cog-
-nizant of the contents of this
Memorandum, considers that two
Main Rooms of the following pro-
-portions are indispensable.-

1 Finishing room for Metalwork 70'×20'
1 Carpenters & Blacksmiths Workshop 100'×20'

these with small rooms attached
may be easily gained by additions
and alterations in the immediate
neighborhood of the Engineers Office
room in the existing buildings:-
they must be upon stoned rooms,
and this may probably lead to ex-
-pense in the necessary modifica-
-tions for adapting the present lower
stories to a superstructure for which
they were not intended. I dont think
that the cost can be estimated fairly
at less than 5000 Rupees, it may
however be less, Lieut. Allen con-
-siders that 3000 Rupees will cover
the whole..

I would endeavor to make
it understood, that the means
at our disposal in the general
workshops described as Iron and
Timber yards, will be available
for the Mathematical as well as
for the Foundry Departments; the
whole being One institution and
controlled by one head; the Mathe-
-matical

=matical Instrument Shops however will require certain Specific appointments and the following articles may in a general way be considered indispensable

2 Travelling Mandrel Lathes say £	60	..	
1 Set of Taps and dies similar to those used by Messrs Broughton & Sons	50	..	-
Grinding and polishing apparatus - Polishing Mops &c &c	45	-	-
Small Tools - Table vices, drills saws &c	75	-	-
Small Stores - Materials and parts of Instruments ready made with a view to more immediate repairs, particularly of Instruments to be received from the Magazines - viz Object Glasses, brass tubes, Steel and Brass wire, Sheet Brass &c &c	80	..	-
Total £	310	-	.
Cost of Carriage &c —	80	..	.
Grand Total £	390	..	.

or say that a Sum of about 4000 Rupees will be required for original outlay on these articles.—

Lieut Allen considers that in the more important division of Establishment of Artificers, viz: the workers in Metal, five men possessing the requisite skill might at this moment be obtained from the workshops, and that an equal number might be collected from the Provinces, who after a little instruction would be fully capable of working in the Mathematical Instrument Department, but the training of an Efficient Establishment will require time, and the amount of work undertaken must be proportioned to the growth of the Establishment

Lieut Allen, however, suggests that the following Scale of Establishment, as one that may be adequate when fully trained, for the performance of the work required

for

for the first few years.—

Smiths	1 Mistry	@	30/ p/mo.	30	..	.		
	2 Smiths	@	20/ ..	40	..	..		
	4 do	@	15/ ..	60	..	.		
	6 do	@	12/ .	72	..	..		
	6 do	@	8/ ..	48	..	..		
	12 do	@	6/ .	72	..	.		
	5 do	@	4/ ..	20	..	..	342	.. .
Carpenters	1 Carpenter	@	16/	16	..	.		
	6 do	@	12/	72	..	.		
	4 do	@	8/	32	..		120	.. .
Total Company's Rupees p/ month							462	..

Both as regards amount of Salary and numbers of individuals employed, the appointment of the above people would be progressive Remarkable instances of Skill and talent ought, however, to be rewarded and secured at a higher payment than is noted in the above Scale; and I would give every encouragement by increase of Salary to those who obtain from the Engineer of the Shops a certificate of the highest qualifications I would, moreover, to men of this description hold out a periodical increase of Salary, say at the termination of every five years of Service: or any table of rates that might be determined on. It is the utter want of prospect in the present system that prevents us from obtaining the services of educated men, who on the first opening in another Department leave us to better themselves.—

As above described the Mathematical Departments would lead to the following Expense.—

Say.	Buildings	5000	..	.
	Tools	4000	.	.
	Dividing apparatus	11000	..	..
	Total Company's Rupees	20000	..	..

with a Monthly Establishment amounting

amounting to Cos Rs 462.0.0.-

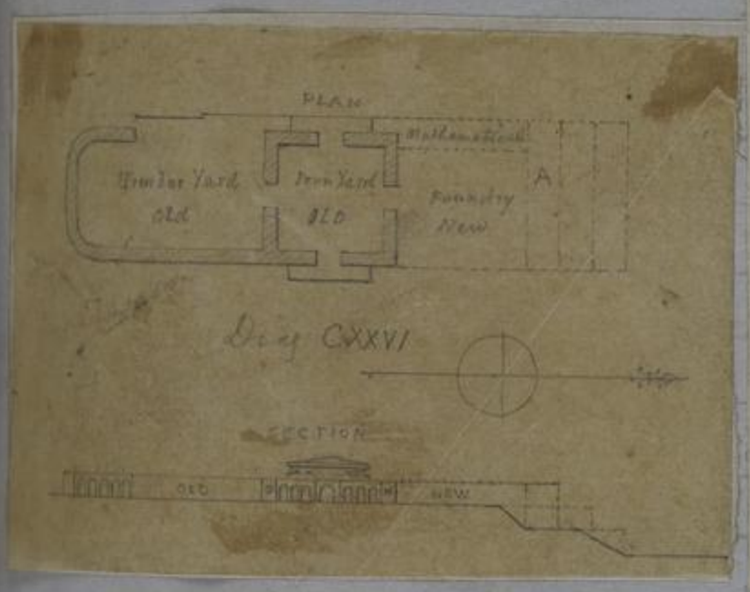
Alder

III. Foundry.-

I have in the list of Establishments included that which may be required for this branch of the workshops, but as I consider that the economical value of a Department of this sort depends entirely on the adoption of both the metal and fuel which are available in the neighborhood, and not in the importation of European products whether Iron or Coke, I would commence operations on a limited scale.- I would recommend that the planning and lining out of the workshops should be designed on an anticipated Establishment of a Foundry, and in the meantime I would prosecute all enquiries as to the nature of the Iron to be procured from the Himalayas, and from the mines to the westward of India; as to its cost on delivery at Roorkee, and as to its comparative merits, both practically and economically with the Iron in use elsewhere.- I have begun to collect specimens of the different Iron ores and metals of the Himalaya Districts; and in connection with the Museum of Economic Geology at Roorkee, to form a valuable ground work for analysis and experiment.- A great deal may be done by degrees in carrying out this examination and practical experiments may be made in the use of Charcoal as fuel for the purposes of a Foundry.

In

In Smelting Iron, Charcoal is ex-
-tensively used in different parts
of India, and up to the end of
the last Century was very generally
used in England. - Its value for
casting rests more on its economical
results than in its insufficiency
for the purpose. - I have in a Dia-
gram below shewn the position
that a Foundry would hold on
the Workshop premises: it would
constitute a completion of the
buildings, as connected with the
Mathematical and those for other
purposes on the Northern face of
the present enclosure. -



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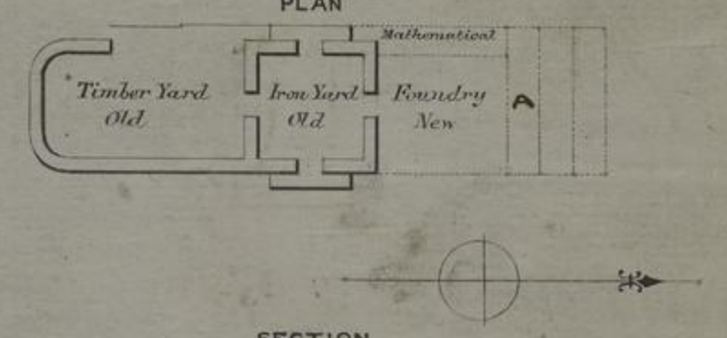

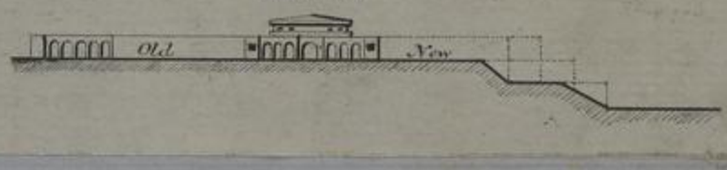

The dotted lines shew the position
of the Foundry with the Mathe-
-matical Instrument buildings on
the West: and others for general pur-
-poses on the North, covering the
steep descent of the ground as
shewn in the Section. - I would
occupy the line at A with Quarters
or rooms for the accommodation
of the Practical Engineers and
Europeans attached to the Workshops,
the presence of whom near at
hand, experience has shewn to me
to be of the greatest value. The
lower stories gained by the peculiar
features

features of the ground, would enable this sort of accommodation to be managed very satisfactorily. The designs drawn out in detail can if necessary be submitted hereafter, but I should Estimate the cost of the whole of these additional buildings not including the Mathematical Shops, to which I allude before; at under 10000 Rupees.

(353, 2 A. vol 2 p. iii c. xii Alder)

The following Table exhibits the Amount of Monthly Establishment that was proposed in the above Memorandum.

Superintendence							
Superintendent of Workshops				₹500	..	..	With Marshy allowance
Deputy do do				300	..	..	800 .. ..
				800			
English Office							
1 Bookkeeper			Rs 150 to	200	..	..	
1 Assistant do				120	..	..	
2 English writers @ 40 each				80	..	..	
4 Chupprassis — (1 @ 6/- 3 @ 5/-)				21	..	..	
1 Sweeper				4	..	..	425 .. ..
				425			
Native Office							
4 Native assistants				50	..	..	
1 General Storekeeper				20	..	..	
3 Moolsuddis				24	..	..	
1 Invoice and Despatch Keeper (Iron Yard)				15	..		
1 do do (Timber do)				15	..	..	124 .. ..
				124			
Iron Yard including Mathematical Department							
1st Foreman				250	..	..	
2d do } Practical men {				200	..	..	
3d do }				150	..	..	
1st Mistrie				30	..	..	
2d do				30	..	..	
3d do				16	..	..	
4th do				12	..	..	
2 Smiths	@ 20/- each			40	..	..	
4 Do	@ 15/- ..			60	..	..	
8 Do	@ 12/- ..			96	..	..	
8 Do	@ 10/- ..			80	..	..	
20 Do	@ 8/- ..			160	..	..	
36 Do	@ 6/- ..			216	..	..	
36 Do	@ 5/- ..			180	..	..	
20 Laborers	@ 4/- ..			80	..	..	1600 .. ..
				1650			
Timber yard							
1st Foreman	(as Carvers)			90	..	..	
2d do	(do)			70	..	..	
1st Mistrie				25	..	..	
2d do				16	..	..	
3d do				14	..	..	
4th do				12	..	..	
6 Carpenters	@ 12/- each			72	..	..	
15 Do	@ 10/-			150	..	..	
20 Do	@ 9/-			180	..	..	
20 Do	@ 8/-			160	..	..	
20 Do	@ 7/-			140	..	..	
20 Laborers	@ 4/-			80	..	..	1009 .. ..
				1009			
Foundary							
1 Foreman							
1 Asst do							
1 Head Mistrie							
4 Asst do							
2 Cutmakers							
6 Laborers & Stokers &c.							

"The preceding list includes all the Establishment that will be required in the Office. Iron and Timber Yards and

Hall

~~88~~

1088

and the Mathematical Department I have included the Mathematical Department Establishment in the annual list for the Dam yard, as the employment of the whole is of one nature; the detail of the Establishment for the Mathematical Department was given before. -

IV. Workshop Office

Superintendence. The duties of the Superintendent and Deputy are of a highly responsible nature; to high acquirements as ~~a~~ Mechanical Engineers, must be added the habits of order and system which will enable them to take charge and regulate the distribution of stores of every description attending upon the Shops. I would if possible select Covenanted Servants for these appointments, but in the difficulty of procuring Men of the class required in the Army, I would endeavour by a liberal Salary and treatment, to obtain the services of Professional Men from Europe. The Superintendent would of course have the control of the whole, but the Deputy who serves under him, would under the plan that I propose be specifically in charge of the Mathematical Department.

Their Salaries as Covenanted Servants would be

Superintendent 500 Rupees per Month.
+100 Rupees marching allowance.

Depty Do. 300 Rupees per Month

The marching allowance of the Superintendent is intended to cover charges for inspection of Timber Cutting in the Forests, and work of

that

that nature to which his attention will be frequently directed

"When uncovenanted Servants (Professional Men) are employed, their Salaries might be left for adjustment at the period of appointment

English and Native Office

It will be understood from what has been said before, that the Institution of these Shops will entail upon the Superintendent the charge of not only an immense quantity, but of a most varied description of Machinery, Implements and Stores, the responsibility of which both in receipts and Issues will rest with the Superintendent. - It is my opinion, therefore, to prevent disappointment of any sort, and to give the Superintendent fair play, he must have at the head of his Office a first rate Bookkeeper. The necessity of having a man of this sort, ~~it appears to me~~ is evident. The appointment is one in fact that is intended to relieve the Superintendent from the drudgery of detail, and to place him in the same position and to give him the same advantages in his immediate Engineering duties, which the Commission for the Department of Public works contemplated in relieving the Executive Officers of works from their duties as Accountants. - To obtain the services of a man of this description it might be necessary to offer a higher Salary than is now accorded to Accountants of Divisions and to retain his services I would hold out to him a periodical increase of Salary. - The Salary might

might commence at Rs 150 or Rs 200 pr Month agreeably to the Qualifications of the Candidate; - with an increase of 50 Rupees a Month at the end of every 5 years of approved good service. - Increase to be authorized by the Government on Certificate from the Superintend=ent of the Shops. - The Assistant Bookkeeper or Accountant would naturally look to the higher ap=pointments for promotion. —

"The 2 English Writers would consist of

1 for the Iron and Timber Yard

1 for the Mathematical Department

The Native Office does not I imagine require any explanation - The Head Native Assistant would control all the Native accounts and pro=ceedings in the Yard; with One General Store Keeper, and 2 Invoice and dispatch Keepers for the sepa=rate departments of the Iron and the Timber Yards. -

"The 3 Mootsuddies would be used in detached duties and in paying Workpeople; these Men would also look for promo=tion to the higher appointments. The Chuprassies and Sweeper could not be dispensed with, the former for the Superintendent and Deputy for messages and other purposes, the latter for the cleansing of the Office and rooms. —

"After a careful examination of the returns and duties of these Shops, I dont think that the above Office Establishment could possi=bly be placed on a lower footing; they, however, to lay great stress upon the

the presence of an efficient Book-Keeper without whom there will be neither order nor regularity — It is, moreover, economy, to make liberal arangements for an Office of this sort, upon which so much of our success depends.—

"The list of Establishment submitted for the Iron and Timber Yards is supposed to meet the wants of the Shops, if kept at work up to the full means allowed by the machinery and extent of the forge and Shop accommodation The entertainment of the Members of the different grades would be a gradual process, and would not be acted upon all at once.

"The Foreman and his two assistants ought to be well educated artificers, and be entertained for General Service, and under no restrictions whatever as to duties, as long as they were confined to the Shops and their wants. Agreements for specific work, or for duties under a specific title, appear to be open to inconvenience as has lately been experienced in the Roorkee workshops, where a man who in his written agreement professed to serve as an "assistant Practical Engineer" (and who from the position of Roorkee had not only had his passage from Calcutta paid by the Government but had received 2 months salary in advance) refused on his arrival at Roorkee to do work, excepting under his own 'notions' as he called his own views, of the duties of an assistant Practical Engineer.—

"For the Establishment proposed for the Timber Yard, the remark

remark made above, on the subject of its being sufficient for present demands, and of its gradual en-tertainment, equally applies. The Foremen I would select from their practice and knowledge of Trades as useful to our object. I have no doubt that 2 efficient men could be easily selected for the purpose from the Army; these men might remain on the Town Major's list as assistants Overseers: or if procured elsewhere might receive the Salary noted in the list.—

I do not think it necessary to recommend any immediate entertainment of Men specifically for the Foundry Department, or the reasons before specified. The Estab-lishment which we hold at present, or rather that which is recommend-ed for the Iron and Timber Yards will give us full powers for enquiry and experiments, and provide us with the means of proceeding on better data than we have at present at some future and some early opportunity"

To the above Memorandum the following abstract of the Expenditure proposed to be incurred both in in-creased accommodation and Monthly Establishments was appended —

Buildings for Mathematical Department		5000	..			
" Foundry		10000	..	15000	..	
Tools &c " Mathematical Dept		4000	..			
Dividing Apparatus do		11000	..	15000	..	
Total Original Expenditure Cos Rs				30000	..	..
Current Monthly Expenditure						
Supervision - Salaries		800	..			
Marching allowance		100	..	900	..	..
Office English		425	..			
Native		124	..	549	..	..
Practical Working Establishment { Iron Yard &c		1600	..			
{ Timber "		1009	..	2609	..	..
Total Cost of Monthly Establishment Cos Rs				4058	..	..

The Roorkee workshops which up to the 31st October 1832 existed as a component part of the Ganges Canal works, were from the 1st of November following, or from the commencement of an official half year separated from them, and placed under the superintendence of Lieut. Allen subject to the Control of the Director of the Ganges Canal works: as an Institution for the use of the North west Provinces: under the following orders. —

That there shall be a Mathematical Instrument Shop and Department for the supply of all Instruments to the Provinces North of Allahabad; that requisitions shall be made on Indent, those in the Survey Department on the Countersignature of the Surveyor General, those in other Departments on that of the Secretary Military Board. —

That there shall be an Iron and Timber yard for the purpose of supplying when such can be done economically all articles required in the Public Departments: that this Iron and Timber yard should relieve the Gun carriage Agency at Futtigurh under emergency, in the manufacture of Instruments for Ordnance purposes, Tools, Locks, &c; in the supply of Tar, and a variety of Articles at present supplied from England and from the Commissariat Department — It should relieve the Cossipoor Foundry in the Manufacture of Fire Engines, Forge

and

and Gun Implements, Weights, & Gauges, Moulds for Rockets and Portfires, Lathes, &c. and it should be a nucleus for supply to the Country, of good serviceable articles at fair rates on private purchase for private purposes.—

That there should be a Foundry for the purpose of supplying Castings to the Provinces North of Allahabad, and of being of general service on Emergency.— For this purpose the Establishment above recommended was sanctioned: with a scale for the Foundry as follows:—

1 Foreman Assistant		150	..	..
1 Head Mistry	@ 30 Rs pr. Month	30	..	..
4 Asst do	@ 15 Rs —	60	..	..
2 Carpenters	@ 10 Rs — .. —	20	..	..
6 Labourers Stokers	@ 4 Rs .. —	24	..	..
Total Establishment for Foundry		384	..	..

Two rules

For the purpose of the Mathematical Instrument Shops and Foundry, with other appendages & buildings which the circumstances of the case appeared to render necessary, especially in warehouse room, and extended accommodation for the Shops in general, the following amount of Expenditure was authorized

Mathematical Shops building —	6000	..	..
Tools for ——— Do ———	4000	..	..
Warehouses, Foundry, with Contingent Buildings ———	15000	..	..
Total Company's Rupees	25000	..	..

No rules

Cummins

With reference to detail on receipt and distribution it was determined that all Instruments received from the Magazines or from Departments, whether new or old should be transmitted in the first instance direct to the

Superintendt

Superintendent of the Workshops, to be by him examined and if necessary repaired. - The Superintendent having satisfied himself that the Instruments so received were in efficient order, and in a proper State for distribution should hand them over to the Principal of the College taking his receipt for the same. The Principal would then either on the report of a Committee assembled for that purpose, or (if such might be considered sufficient) on his own examination receive them into the Depot, and from thence issue them to the different Departments; on the countersignature of the Surveyor General in the case of the Survey Department; on that of the Military Board otherwise. - This will of course necessitate the building of Store rooms which is included in the above Estimate of 6000 Rupees, 1000 Rupees in addition to my original Estimate having been added for that purpose -

For the increased quantity of Stores &c which the new System would call for in the Timber and Iron yard, an additional 5000 Rs which is included in the third item of the detail of cost above given was added to the Estimate - The arangement for the receipt and distribution of these Stores was that they should be issued (as is at present the case in the Magazines) on Indent countersigned by the Military Board; Emergent Indents being (in consequence of the distance at which the Board is situated from Roorkee) immediately attended to by the Superintendent who is to report the same without

loss

loss of time to the Military Board.
With reg and to the Ganges Canal
works it was ruled that they
should hold a prior claim
upon the Roorkee workshops, and
that their demands for work or
stores should supersede all
others; and that the Officer for
the time being, holding Executive
charge of the Northern Division
as well as the Director and Superin-
-intendent General of Canals should
have unlimited power in pro-
-curing the aid of the workshops,
and that calls from these Func-
-tionaries should be attended
to in preference to those from any
other Quarter.—

The System of Accounts
which I recommended was that
adapted to a Manufactory, as
carried on by Private Individuals,
the plan of which was suggested
and the detail drawn up by
Mr Marten, the Head Assistant
in the Office of the Director of the
Ganges Canal works, whose plan
of Accounts for the Department
of Public works was so highly
spoken of by the Committee
of Enquiry into that Department
under the Presidency of Major
Kennedy. This plan of account
keeping will be found in the
Volumes of Tables.

The design of accounts
and the system of dealing with
Individuals Public or Private,
was to get rid of the delays
which had usually accompanied
the purchase and receipt of
Articles through the Military
Board. Cash payments and
Settlements

settlements of accounts for articles supplied, instead of procrastinated paper records, with settlement indefinitely postponed, were the corner stone and basis of the whole structure; it was founded on the propriety of having all accounts settled at once, of + making the Shops at Roorkee a depôt from whence all im-=plements and stores required for the Public works may be purchased by Executive Officers, who would buy, pay for, and charge to their account at once in the Bills for works upon which they were engaged. It would relieve the Executive Officer from the anxiety of a position which he has always held, as to the Balances against him in the Ordnance Books; he would pro-=ceed from year to year with a clear Balance Sheet, and when his departure from Office, or period for taking furlough arrived, he would at least be free from any anxiety on the subject of unexplained arrears

On the 1st November 1832 therefore, the workshops at Roorkee commenced a new series of in-=dependent duties although their connection with the Ganges Canal works there in progress, and their occupation on wood and iron work solely for Canal purposes would for some years curtail their general usefulness. The enormous demand for bricks not only for the Solani Aqueduct and the work directly appertaining

=taining to the Ganges Canal, but for the College buildings and numerous Bungalows under con=struction for students rendered it quite impracticable at that period to make any active movement in the building which was called for by the newly or=ganized Institution. At that time, therefore, the Shops were ne=cessarily limited to their engage=ments, and to the accommodation that they previously had. The designs for the new buildings, however, were placed in the hands of the Executive Engineer so that when opportunity offered he might carry them on, if only by slow and gradual means. This has in fact been done, the basement stories of the Northern face, a well, and certain other buildings at=tached to the Foundry and Mathe=matical Department have been in slow progress. The clear=ing off of the Solani Aqueduct works, and the completion of the College buildings, both of which unfortunately had to be simultaneously carried on, will lead to the rapid finishing of all the buildings and improve=ments required for the shops.

In the meantime the arangements for the receipt of Instruments from the Magazines, and the Establishment of the Depot at the College have been necessarily placed in abeyance In fact at the period that I am writing, although a good deal of the initiative proceedings have been gone through, and the ground work has been laid for ultimate progress, these workshops are es=sentially

-sentially in their infancy, and may be considered as by no means introduced to the Public as an Establishment for general utility -

Before closing the account of the workshops in their new position, I may remark on the arrangements for money advances, and the possession of Capital, as we may term it in this case, which the Superintendent of the Shops holds for carrying on business. -

As, on the separation of the Shops from the Ganges Canal works nearly the whole of the work done by the Shops was for the Canal; the Executive Engineer of the Northern Division of the works was directed to make advances of even Sums of 10,000 Rupees, these Sums being, in fact advances on a running account, that must necessarily exist between the Canal and the workshops. The same system would be adopted where any Public Establishment drew largely or regularly on the Roorkee workshops for supplies. Advances for instance, must be made to the Shops for the manufacture of Fire Engines, Lathes and Tools, for which orders are received from the Military Board. In the latter case, and in all others where Articles are manufactured for the general purposes of the State, these advances would be made by assignments given by the Accountant General North west Provinces, in the same form as

Assignments

assignments are now given to the Canal Departments for Current Expenses:- viz:- by application by the Superintendent of the Workshops to the Director of the Ganges Canal Works, who would hold in his hands the power of acting on an Annual Assign-ment granted by the Government on an Annual Estimate submitted by the Superintendent of the Workshops through the Director. The amount of this Annual Estimate in the early period of the Shops operations must necessarily have been uncertain. It was clear that if advances were received in the Workshops Treasury from Public Departments for everything manufactured for their use, or if everything manufactured for original issue was sold to the Public, the only assignments that the Government would be called upon to give would be a certain Capital in the first instance to carry on the manufacture of Articles, and for monthly Establishment.- The first of these would be gradually decreased in amount as the Sales of Articles took place and the latter would in all probability cease, from the Factory being able to pay its Establishment from its own receipts. At the commencement, and during the early period of progress, the following arrangements were determined on.-

1st. All purchases of Stores such as Iron, Timber &c should be made on Estimates advances for

for which an application for an assignment would be submitted by the Superintendent on the 1st of May annually

2nd That all purchases of Machinery or implements required for the different Departments of the workshops should be procured in a similar way; in the way in fact which is now done elsewhere; viz.: by submitting an application to Govt. for permission to purchase, and by obtaining an assignment for the purpose—

3rd That until we hold better data than we have at present the average cost of Labor and Sundries for the last 12 Months including the increased Salary to Superintendent &c. should be taken as the probable Monthly Expenditure on these items; and that power should be given to the Director to grant periodical assignments in sums the total of which should not exceed that monthly average

Average Expense per Month	6500 0 0
on Labor and Sundries	
Do on Regular Establishment	1500 0 0
Total per Month Rs	8000 0 0
Total per Year Co's Rs	96000 0 0

The total per year as above noted, being the amount of Expenditure for which an annual assignment will be granted.—

On the above rules and with the Authorized Sum as above noted, the Roorkee Workshops have been carried on up to the present period. The arrival of a Successor to the Practical Engineer who

who accompanied me from England, and who returned at the expira=tion of his service; as well as that of a very superior workman in the Mathematical Instruments Depart=ment, have placed us on an ex=cellent footing in preparation for more extended proceedings on the completion of the New ac=commodation. The former, Mr Watson gives promise of being a great acquisition in all de=partments, he has established the certainty of success in Iron casting, and has with a small Cupola temporarily erected, done a good deal of work, which must otherwise have been made at a distance. — The latter, Mr Cribble was for a long time in the Surveyor General's Office in Calcutta, em=ployed on the repair of both Sur=veying and Mathematical In=struments, and even with the want of room and conveniences which he has experienced, he has turned out articles in the shape of Small Surveying Circles or Circumferentors for the use of the Natives, and other descriptions of common Instruments that would do credit to the professional Ar=tist of London. — I believe that these Shops only require to be completed, with proper accom=modation for the different de=partments to which they are destined, to do full justice to the intentions of the Government.

Early in 1833, the follow=ing Machinery in addition to that which was formerly received, was ordered from England

A 20 Horse Power High pressure
Beam Steam Engine
A Slotting and paring Machine
A Small Drilling and Boring do
A Small Planing do
A Plate bending do
A Large Self acting Lathe.—

The Engine will be at=tached to the Foundry Yard and in connection with the Mathe=matical Department, and it is by no means improbable that it will be found convenient in economizing space to remove the Northern Wall of the Old Quadrangle or Iron Yard, and by so doing, to throw the Foundry and the Quadrangle area into one Enclosure.—

My original idea of having Quays and fixed Cranes on the side of the Canal in connection with the workshops will also be greatly improved by a propo=sal of Lieutt Allen's; viz: the constructing of a Dock in the Centre of the Timber Yard, con=nected with the Canal by an open Channel bridged over the Canal bank and berms.— The site of this proposed improvement is shewn in the Plan of the workshops Plate LIX Atlas.— It will enable goods to be floated into the Yard and give us the means of loading and unloading within the precincts of the workshops, and in the immediate neighborhood of the warehouses; it will also give great advantages to our Boat building operations in floating the boats away as soon as they are built. Practically speaking

Speaking the construction of this
work will be an economical one,
as it will in the excavation for
the dock and Canal of approach
to it, give Earth for raising and
Levelling ground in the yards,
which in spite of the Quantity
of work of this description that
was done in the early stage of
our proceedings, is very much
wanted. The only inconvenience
that I see to this side Channel
which will leave the Canal at
the Commencement of the Ogee
on the approach to the Bridge,
is that its mouth will be a har-
=bour for Silt deposits, and that
by opening a passage through
the workshop wall for the Canal,
ingress and egress will be obtained
In the former case, the Silt clear-
=ance would be effected at periods
when the Canal was laid dry,
and the Silt itself if not re-
-quired elsewhere, would be
thrown into the main Canal
bed on the down Stream side
of the Dock Channel head, as
it could not be allowed to in-
=cumber the Esplanades or road-
=ways. In the latter, provision
might easily be made in the
shape of a Portcullis or some
protective expedient by which
ingress into the Yard by that
passage would be prevented

By referring to the
map of Roorkee, it will be
seen that I have reserved spare
ground to the South of the
Timber Yard, and not allowed
it to be occupied by either pri-
=vate or public buildings, the

road

road which has been carried
across it having been allowed
merely as a temporary conve=
=nience. My object having been
to retain the whole of the land
in the neighborhood of and
parallel to the Canal for pur=
=poses of workshops, so that the
enclosure or buildings required
for its purpose may be collected
in one compact mass. That
portion of this ground lying
in close proximity to the Private
Estates on the East, and which
lies out of the alignement of
the East wall of the Quadrangles
has been proposed to be occupied
by the Quarters of the European
Establishment attached to the
yard; the flat roofed buildings
connected with it, on the north
East Angle of the Foundry, being
considered as more applicable
for providing additional accom=
=modation to the Shops, than
to that of private residences.
Thatched roofs and a free cir=
=culation of air are certainly
more adapted to salubrity, than
a Series of connected rooms
attached to the body of the
workshops Buildings. The ground
at the present time is occupied
by Timber, it is separated from
the Timber Yard enclosure, by
the high road and ramp of
approach to the Bridge, an im=
=pediment which can be easily
overcome by a passage of com=
=munication built under the
road. This with the free use
of rails, a quantity of which will
on the completion of the Canal
works

Works, be dispossable, will connect the whole of this extended line of shops and yards in one convenient series.-

Mder

At present the Model Department and Libraries both Professional and Non professional are under the Executive Engineer of the Northern Division of the Ganges Canal Works, although the rooms form a part of the workshop buildings. These are specifically for the Canal Department, and for Study and reference for the Students of the Civil Engineers College.- A Librarian for whom a Salary of Rs 50 Rupees a month is allowed by the Government has not yet been entertained.- The present State of the Libraries, and the small number of books contained in them, hardly called for a substantive appointment of this sort, the duties having been performed by the Head Writer in the Executive Engineer's Office on a reduced allowance. A list of the Books will be found in the Volume of Tables.-

The Model Room is at present by no means fully occupied, and its contributions are chiefly Models of Works which have been built on the Canals in these Provinces. Its nucleus may be dated as far back as 1831, in the model room of the Eastern Jumna Canal, which progressed under my successors and ultimately was removed in mass to Roorkee. It possesses, nevertheless, some interesting Models besides those of

of Canal works, and as a be=
=ginning to a more perfect
Series is satisfactory.-

The Clock Tower the base
=ment story of which acts as
the vestibule from the open es=
=planade which lies to the East
of the buildings, is built on a
design by Lieut. George Price
a Deputy Superintendent in
the Canal Department, the Arch.
=itect and Designer of both the
Church and the College; it is
a neat plain building campanile
fashion, in so far that although
in contact with the mass, it is
built separate from the main
building of which it forms a
part.- The Clock is an Eight
day one made by MacCabe
with 4 faces, and with a strike
that is heard very distinctly
over the whole extent of the works.-

In conclusion, I may
observe that nominations of
Officers to the workshops have
been confined to those only who
have appeared to possess peculiar
claims for the Office, vacancies
still exist, which may be filled
up as opportunities offer, but at
an out of the way place like
Roorkee, removed altogether from
contact with Calcutta or any
of the large Towns of India,
we are in a measure cut off from
connection with men who are
fitted to the work; a greater dis=
=advantage, perhaps, is the abso=
=lute necessity for procuring
men at a great expense from
distant points, on certificates
of character, and professional
Knowledge

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Knowledge, which experience may point out to be altogether fictitious; this is an evil to which we are open at present, although the extension of railroads, and dependent on them, the introduction of practical Engineers in the Country may place us on a different footing hereafter. In Lieut. Allen as the Chief we have in all Departments of Machinery an excellent Superintendent; in Mr Watson as a Practical Engineer, we have a Young rising man with a great deal of Professional Knowledge, backed ~~by~~ by other acquirements which render him worthy in every way of maintaining a high position in the Workshops. In Mr Crible the Mathematical Instrument maker we have an equally efficient member of our young Establishment. We require more aid, however, and I consider that this can only be satisfactorily gained, by a deliberate selection of men. The following Table will exhibit the present State of our European Superintendence in the workshops with the vacancies still existing. —

Lieut Allen - Superintendent
" Read - Acting Depty Do
Mr J.L. Watson - Practical Engineer
" W.S. Crible - Assistant Mathematical Instrument Department
" Corrigan - Bookkeeper
" Pigott - Assr Do
" Pocock - Clerk
Serg[t] Neilson - Assr Foreman Iron Depr
" McArthur - Store keeper
Corpl Aitchison - Moulder

Vacancies

1 General Musters
1 Assr Foreman Timber Yard
1 — do — Founding
1 Clerk —

Lieuts Read of the 50th Regiment N. I. a Deputy Superintendent in the Canal Department is at the present time acting as an assistant to Lieut. Allen.—

It does not appear worth while to pay any specific attention to the temporary workshops that have during the progress of the works been attached to each of the Divisions. both they and the Divisions themselves hold tenure merely on the progress of the works, and will be broken up and discontinued on the new organization of the Establishment depending on Irrigation. Their occupation has been chiefly confined to the common routine duties of each Division, making Doors for the Chokis buildings, woodwork for the Sluices and Regulating heads - and all woodwork required for Divisional purposes. —

Section II. Mills

The only arrangements which have been made for machinery of this description are for grinding corn, and the machinery itself is the common Punchukki, or native corn mill of these Provinces. Buildings for this purpose have either been constructed, or are in preparation for construction at the following places. -

Kunkhul
Bahadoorabad
Nissoh Nuggur
Muhmoodpoor
} Saharunpoor District. —

Belra Davli Chitoora	}	Muzzuffurnuggur Dist.
Sulawur Bhola Dasna	}	Meerut District
Pulra Simra	}	Aligurh District
Cawnpoor	Terminus - Cawnpoor Dist	
Etawah	Do	Do. -

The merit of the Punchukki is its exceeding simplicity, its perfect adaptation to the natives who are called upon to use it, its excessive cheapness and the ease with which it is replaced or repaired; its defects are loss of power, in requirements for a large body of water than would be necessary with the Turbine - These defects, however, are in our case negatived by the Mills being placed in such a position that the water in its progress down the Canal passes through the Shoots of the Mills, and rejoins the parent Stream through their waste Channels, with the Quantity of Fall, therefore, that we have, and with water sufficient for the purposes of the Punchukki, much as I esteem European ingenuity and invention, I have preferred supplying the native of India with his own simple mill the use of which he perfectly comprehends, and the repair of which he can effect either by his own means, or by those of the nearest village Carpenter. Turbines, &c., may come hereafter, and will I have no doubt do so with great advantage to the rising generation -

The

Strahan

The only deviation from the above rule of the water proceeding through the Mill Shoots and rejoining the Canal through the waste Channel of the Mills themselves, is in the Establishment at Kunkhul. These buildings have not yet been constructed but should they be so, their situation on the edge of the branch of the Ganges just below the Town of Kunkhul, will militate against the above economical principle In this case the water after passing through the Mills will run into the branch, and although not actually to waste, as providing the means of irrigation to a quantity of low ground that lies in the neighborhood, the principle is opposed to the practice which I desire to see accomplished. My only object in fact in estimating for Mills at Kunkhul was to give a ready supply of flour to the inhabitants, and I did this even to the neglect of a principle, in consequence of the Main Stream of the Ganges being in such close proximity that additional water might be admitted into the Canal Channel to meet the demand of the Mills. —

The design for the Kunkhul Mills is shewn in Sheet XVII, Atlas; it is similar to that figured in the Estimate of 1845; it consists of an octagonal Basin with its lateral faces occupied by Mill buildings, the 2 remaining sides acting as the ingress and egress Channels. The design

gives

gives Space for 16 pairs of Stones which will grind in the aggre=gate from 800 to 1000 Maunds of Corn a day. - Supplementue to this nest of Mills, more es=pecially for the use of Kumkhul the Town of Burdwan will be supplied by detached Mills, which may be built either by the Government or by Private Contract on the Branch lying between the Main Stream of the Ganges and the regulating Bridge and Dam at Mygapoor.

The Bahadoorabad Mills are built upon the Site of No 1 Lock, as designed in the Project of 1815 - They are situated between Dowallapoor and the Village of Bahadoorabad, at a distance of a Mile from the latter - Here there are arangements for 16 pairs of Stones. the Mills lie on the right and left of the Navigable Canal into which the Waste water passes The Head of these Mills is situ=ated on the high levels above the Ramipoor Superpassage, and the Reservoirs connected with them are supplied with outlets from which water for Irrigation can be delivered to the neighboring village lands. - These works are in progress of construction.

The Mills at the places noted in the above list from Assoffnuggur to Simra, are connected with the Waste Cham=bers of the Locks at the different Falls, they are built on one de=sign, and in construction the revetment Wall connected with the Canal face is so ~~designed~~ laid out that

that additional Mill buildings can be added afterwards, should an increase to the number of Stones be desirable.- At each of the Locks above alluded to, there are 2 Mill houses, each of which contains 2 pairs of Stones; the supply for the wheels is received from the higher levels of the Lock, and the water passes off into the Lock waste Chamber.-

The Terminal works on the Cawnpoor and Etawah lines are constructed on a similar principle to the above, the buildings are, however, detached from the Locks and line of Canal from which they are separated by the Esplanade or Open road which flanks the Canal Channel They receive their supply, however, from the high levels, and pass off their waste water on the lower ones - A plan of One Punchukkie however, is that of all, they differ in nothing excepting in length of Shoot depending on the Amount of fall of water passing upon the wheel and in the arangements necessary for the discharge of waste water

I may conclude this Chapter with a short account of the native water mill, which was published by me in the year 1833 in the Journal of the Asiatic Society, as without any disrespect to Turbines and other ingenious devices, I have always considered, and do still consider the Punchukkie of the North West Provinces of India, a Machine possessing ex-

=traordinary

=tra ordinary claims for adoption amongst a class of people like those with whom we have to deal in the Canal Department

" On the mountain Streams and Rivers in the Northern Doab, the natives use a water mill for grinding Corn, which from its simplicity is well deserving attention. It might be applied in all countries, where a sufficient ~~quantity~~ fall of water can be commanded ~~and~~ Where a want of efficient workmen renders the ~~repair of~~ complicated ~~and expensive species of mill~~ machinery ~~difficult, the Punchukki~~ ~~generally used also~~ would be of great service ~~where a matter of difficulty to~~ ~~manage or keep in repair~~. In the hands of the natives and with the rude means at their disposal, it may be perhaps considered the only sort of mill that could be turned by them to any account, ~~both from the absence of any complication in its parts, and~~ From the simplicity of its construction ~~and~~ ~~if can at a trifling outlay be fixed~~ ~~on any Mountain Stream for a~~ ~~or removed at pleasure~~ ~~trifling outlay, either to fix his~~ ~~Mill at any point that may suit him, or to remove it at pleasure~~. The only weighty parts ~~the Punchukki in fact are~~ about the Mill Stones, which (by running a stick through them, and yoking to it a Bullock or pair of bullocks) may be removed with as little difficulty or expense as the rest of the machinery.

A horizontal water wheel with floats placed obliquely so as to receive a stream of water from

from a Shoot or funnel, the said floats, being fixed in a vertical axle passing through the lower Mill stone, and held to the upper one by a short iron bar at right angles, causing it to revolve with the water wheel; the axle itself having a pivot working on a piece of the hardest stone that can be procured from the shingle near at hand: this with a thatched roof over it, and the expense and trouble of digging a Cut so as to take advantage of a fall of water, are the only ~~articles required in~~ requirements for this very simple Mill. The plan is so obviously good, not only for the means gained, but ~~for its possessing a~~ also from the simplicity which renders it ~~very~~ the whole almost independent of repair, and it is moreover so intelligible in its parts as to come within the comprehension of the simplest understanding. ~~The~~ The Paperchukki has been adopted generally in all the Canals in the Delhi District as well as in those of the Doab, and with such success, that its introduction ~~of such Mills wherever sufficient fall is provided~~, is as much an object, on account of the profit arising to the Canal returns, as from the accommodation and convenience offered to the community, in providing the means for grinding corn.—

"On reference to the accompanying Plate, it will be seen that the ~~motion is only one motion~~ motion is direct, and that ~~supposing~~ the ~~Materials~~ ~~are~~

adjustment
~~as a~~ whole, the ~~p~~permanency of the machinery depends entirely on the lower pivot. It will also be evident that there is not a part of the whole machinery that could not be repaired and put in perfect order by the com=monest village workman, a matter of importance in the absence of mechanical skill and practised workmen. Where=as in the plainest undershot wheel applied to a mill for grinding corn, there are no less than 3 wheels of different des=criptions; the change of vertical to horizontal motion; and three pivots ~~to keep it in order~~, with ~~a~~ friction, even under the most skilful management, tending constantly to disarrange the parts, and render the ~~accompa=~~ presence ~~=niments~~ of a forge and black=smiths shop ~~absolutely necessary~~ indispensable ~~to keep the mill in order~~.

"On the Canals it has been found worth while to construct permanent buildings for these Corn Mills, and although keeping most strictly to the original simplicity of the Ma=chinery, they are set up with greater care, and means are given for regulating the motion &c which renders the whole as perfect as it can well be.

"It would appear that a fall of water (that is to say, the difference of level between the surface of the head supply and the float boards of the water wheel) equal to 3 feet, is the minimum in which this species

species of Machinery can be used with any good effect; and it has been found that with a fall of three feet, the dimensions of the Shoot or funnel require an addition in width, to obtain that by weight of water, which the smallness of the fall will not give by velocity alone, ~~and in the dimensions of Shoot given to those of a higher class~~.

"The following are the particulars of Mills on the Eastern Dumna Canal, divided into three classes ~~flowing~~ depending on the depths of the fall; the width of Shoot on the Sill or waste board, being 12 Inches, and the discharge pr second averaging 1·5 Cubic feet: the diameter of Millstones 27 Inches, and thickness 12 Inches. the Corn being ground into Atta or coarse flour.—

Class	Fall of Water		Atta ground per hour		
	Feet	Inches	Mds	Srs	
No 1	7	6	1	26	or lbs 132
2	5	6	1	5	" 90
3	3	6	0	17	" 32

The Common Mills used in the Dumna and mountain Streams are said to grind from 5 to 7 Maunds of Atta pr day, or in 24 hours; the machinery being of the rudest description, the supply of water being very small, and a great part of that escaping through the Shoot before it touches the water wheel.—

The returns to Government on the Mills is obtained generally by farming them out to Contractors for fixed periods, who pay so much pr day as long as a

Dawson

a supply of water equal to that entered in the Contract is provided, re-
-gulated by the depth of water on the Sill or waste board, this return of course varies not only ~~from~~ with the powers of the Mills, but also ~~from~~ with their position re-
-latively to populous Towns and Cantonments - In the neighbor-
-hood of Delhi the ~~return~~ demand for atta is great, and ~~the consequent return~~ ~~demand for atta~~ equal-
-ly so; - whereas at other points dis-
-tant from Towns, Mills of equal power ~~would~~ do not produce half the return. - The Eastern Jumna Canal, although possessing every advantage in fall and power of machinery, labors under a disadvantage in this respect, the Town of Saharunpoor being the only one throughout its whole extent where there is any great demand for machinery of this description. - Thanli, although a large Town, does not contain a great number of that class of people who purchase atta, each family grinding their own Corn for home consumption; and although there are ample means for establishing Mills at the South end of the Canal oppo-
-site Delhi (the Canal falling into the Jumna with a descent of about 50 feet in a line of 12 Miles!) it has been considered unadvisable to put them in ex-
-tended practice, on the supposi-
-tion that the Mills already built on the Delhi Canal in the City would suffer from the com-
-petition; in short, that the Mills

in

in Delhi are sufficient to grind the corn required by its population

The people from whom the Millers look for Profit are chiefly those of the Sipahi class, trav=ellers, those without families, idlers &c. Those who are regularly settled with their families, trust=ing ~~as I before said~~ to the hand Mill in their own house, and not purchasing from the Mills excepting on Marriages and other grand occasions, when the consumption of atta is more than their own Mill could provide for.- In Military Cantonments the whole of the Atta and flour used is obtained from the Mills; the vicinity therefore of a Station of this description becomes a lucra=tive affair to the Miller, in ex=emplification of which I may mention, that during the existence of the Provincial Battalion at Saharunpoor, the Canal Mills at that place were kept constantly in their service, with little or no aid from the inhabitants of the Town.-

The profit derived by the renter of a Mill depends in a great measure on his manage=ment, and on the rate per Mauna which he charges for grinding; but with an experienced and steady man, the following may be considered as a very close apr=proximation to the daily profit. The rate per Mauna for grinding atta by the Peesunyaris or Corn grinders in the City, is generally 3 annas, for which sum they de=liver the Article at the purchasers house.

house; at the Water Mills 2 annas per Maund is the usual charge, not however, including the carriage of the grain to the Mills &c, the charge of 2 annas being simply for grinding.

The expenses to the Miller for keeping 2 Mills at work are thus:-

Per Month.	1 Head Millers wages	5	..	..
	1 Assistant do	4	..	..
	1 Weighsman	4	..	..
	Oil at ½ a seer a day about	1	..	..
	2 Seers of Atta given per day to 2 Millers in addition to their regular pay - about	2	7	..
	Total Expense per Month.	16	7	..
Or per Day.	taking a month of 30 days	..	8	9⅗
	The receipts per day are as follows:-			
	Supposing 55 Maunds of Grain ground @ 2 annas per Maund	6	14	..
	Deduct			
	Expenses as above 0 .. 8 .. 9⅗			
	Government rent 5 .. 0 .. 0	5	8	9⅗
Balance	Profit to Miller per day Rs	1	5	2⅘

~~As the above daily expenses would not be increased by~~ An additional Mill would increase the profits to the Contractor ~~would be proportionate~~ without a proportionate increase to the Expenditure; whereas a Solitary Mill would ~~very nearly~~ require the same Establishment, as that noted in the above table would, therefore be less profitable, Mills of a higher power also might be easily worked on the above Scale of Establishment.

At Mills distant from Towns, the payment for grinding Corn is made in kind, varying from 2 to 4 Seers per Maund; which, at the usual rate of from 40 to 50 Seers per rupee, is but a moderate return in comparison with that of the Town Mills. These village Mills grind gram barley and Indian Corn as well as wheat.

The

The Stones used on the Canals are chiefly those from the quarries near Agra, Roopbas, and Futtipoor Sikri, a coarse grained sandstone which requires the Chisel every second day, there are 3 Sizes used

1st Size Diameter 36 Inches - Depth 12"
2nd " do 30 do do
3rd " do 27 do do

the two latter are in most general use. Stones of the usual quality last for about 2 or 3 years, that is to say, at the end of that period a new upper stone is provided, and the old one placed below.- In the native Mills on the Jumna, stones about 22 Inches diameter, and from 10 to 12 Inches thick, are quarried in the vicinity of Rajpoor, north of Deyra; they appear to me of an inferior description, though of various qualities; the native Millers, however, prefer some of them to the Agra stone, and it is not impossible that some of the best variety from Rajpoor may be superior to the worst from Agra, but generally speaking the preference is decidedly in favor of the latter.

The best method of delivering the water from the Shoot on to the float boards, appears to be that represented in the accompanying Sketch, and which has been generally practised on the Canals in pursuance of the usual course adopted by the Natives. A trial made at Hansi, in which a horizontal (or nearly horizontal) shoot applied to the lower part of

of a cistern delivered the Stream on float boards whose planes were praiallel to the axis of the arbor or upright, did not answer so well as was expected, owing in a great measure, it was supposed, to the introduction of a new System, which unless pralprably advantageous, is certain to meet with objections from the people to whom the Mills are entrusted. I am much inclined to consider that the latter method is not only objectionable but that the power obtained in applying it to this simple waterwheel is much less than the other; a matter to be settled by practical experiment and not by theoretical Speculations Belidor, in speaking of a Mile of this description, says, "En Provence et dans une bonne partie du Dauphiné, les moulins y sont d'une grande simplicité, n'ayant qu'une roue horizontale, de 6 ou 7 pieds de diametre, dont les aubes sont faites en cuillerès* pour recevoir le choc de l'eau, qui coule ordinairement dans un auge; L'arbre, qui repond à la meule supérieure, est la seule piece qui sert á lui communiquer le mouvement, et je ne crois pas qu'il soit possible de faire un moulin à moindre frais; il est vrai qu'il faut pouvoir menager une chute comme celle que l'on voit ici, et qui sont tres frequentes dans ce pays là. — "La

*These Cuillerès, or spoon shaped ends, are mere indentations in the Native Mills, and the trough alluded to by Belidor for the delivery of the water at an angle of about 25° is in the Native Mills a square tube or shoot placed at an angle of 45°. The Crapaudine and the arrangement for raising or depressing the upper stone by the transom in which it is fixed, is also practised in the Native Mills

"La roue tourne sur un pivot dans une crapaudine pratiquée au milieu de l'entretoise du chassis, servant à approcher les deux meules, par le moyen de la vis se qui est a l'extremité de la piece, et de l'ecrou, que l'on fait + tourner pour hausser ou baissir le chassis

"Les roues que l'on voit exécutées dans la gont de cell ci ont leur + cuillerès simplement assemblées a l'arbre par un tenon et une cheville, fortifiées par le dessous par des membrures qui les entretiennent toutes ensembles". — Be goes on to explain a method of opening and shutting the water course or shoot, which is of no consequence here. It will be seen, however, that this Provence Mill is exactly on the same plan as that used in this part of India, and it is a pity that the account did not proceed and explain the powers of the Mill, that we might draw a comparison between the two. It would also be interesting to know whether the increased size (the Provence Mill being about double the size, in diameter of waterwheel, &c.) + would not detract from the simplicity of the little native Mill; for the great advantage of the latter appears to be the absence of complicated wood and Iron work, especially joints and iron bindings, &c., all of which increase with length of lever, or length of radii of the water wheel: indeed the above account shews a complication of Membures, &c., which in the native Mill is not thought of". —

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Diag: CXXVII.

SKETCH OF WATER MILL

for grinding Corn

as used in the Northern Doab

Fig. 1

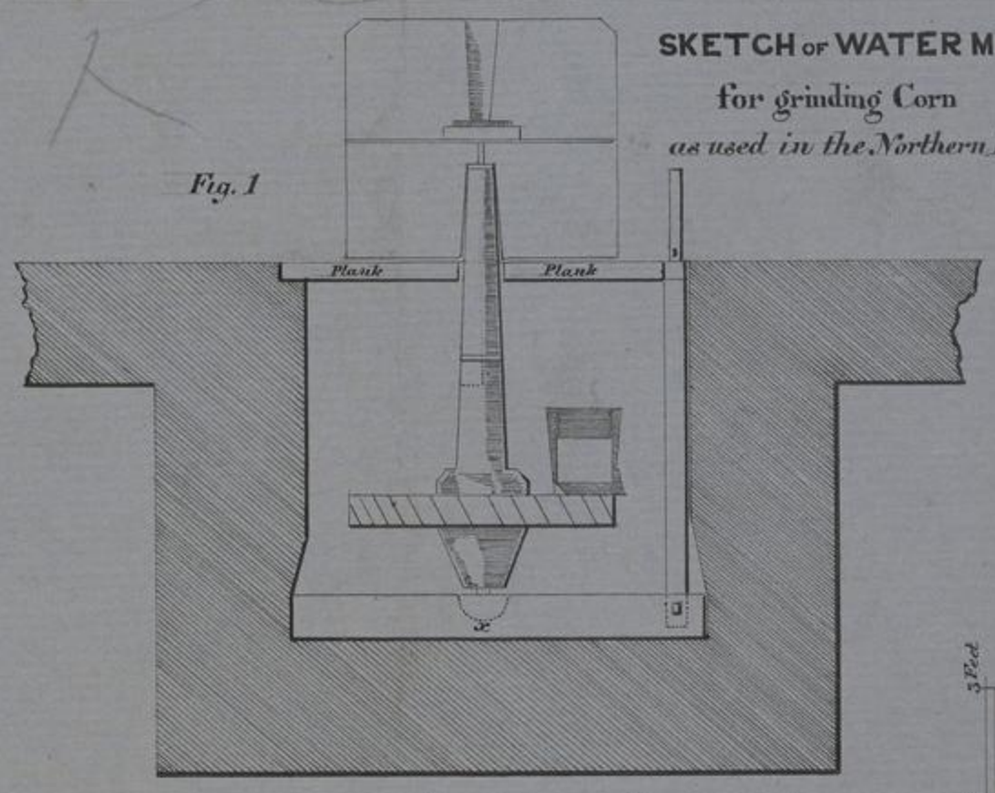


Fig. 2

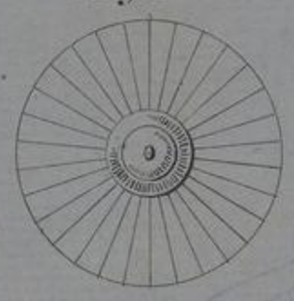


Fig. 3

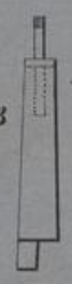


Fig. 9

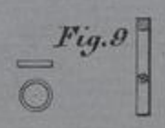


Fig. 10

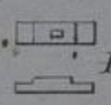


Fig. 8

Fig. 4

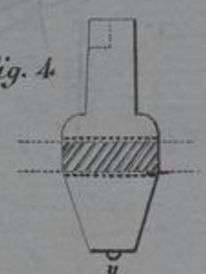
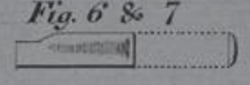


Fig. 5

Fig. 6 & 7



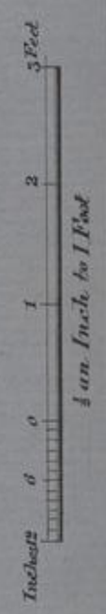


Fig. 11

Scale ½ Inch to 1 Foot

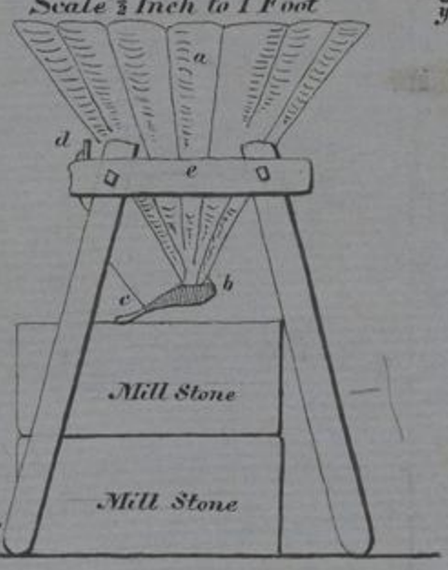
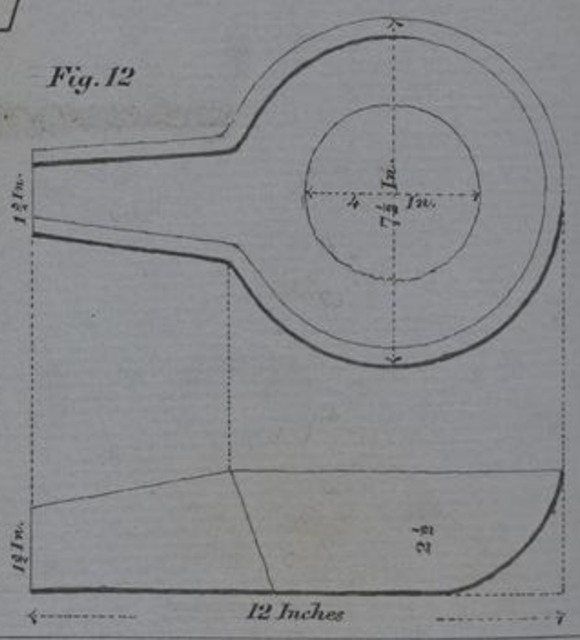


Fig. 12



References to Plate

CHAPTER VIII

Fig: 1. Elevation of the water wheel, with the stones in section to represent the iron spindle.—

At x, a hole of about 4 inches diameter and 4 inches deep is made in the transoms, into which a Quartz boulder is firmly fixed; the said stone or boulder having an indentation made in it to receive the pivot.—

This pivot, as represented in Fig: 4, consists of another stone of the same quality of about 4 or 5 inches long and 1 inch square, which is firmly fixed into the tail of the arbor (see Y). The above stones are picked up in the beds of the mountain rivers, and are used as they are found without any stone cutting.—

Fig: 2.— Plan of waterwheel, 30 float boards of Sissoo wood.—

Fig: 3.— Upper joint of arbor

Fig: 4.. Lower joint of arbor, shewing the Iron straps fixed between each float board, to keep them firmly in position, the straps represented in Fig: 5.—

Fig: 5.— Straps as above.—

Figs: 6 and 7.— Float board and end of ditto. the float board 12 inches long, with a spoon sunk 4 inches.—

Fig: 8.— Iron ring that slips over the top of arbor, and holds the two joints together

Figs: 9 and 10.— The spindle and plate upon which the upper Mill stone turns

Fig: 11.— Sketch of Mill stones with basket stand, &c.—

a.— Hopper or basket

b.— Shoe

c.— Feeder, or small piece of wood hanging to one lip of the Shoe, and resting on the Mill Stone, each revolution of which gives the shoe a jog, causing the corn to run constantly from the hopper through the shoe

d.— String attached to the opposite lip of the Shoe, to which the feeder is, and by tightening or loosening which, the discharge of corn is regulated.—

e.— Stand

Fig: 12.— Shoe on a large scale; this is generally cut out of a block of Oak (Buteâ frondosa), or any wood easily worked.——

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CHAPTER VIII.

Terminal Works

This chapter may be divided into the following.-

Section I. Works at the Cawnpoor Terminus
II Do Etawah Do.
III Do Termini of the Branches
A. Futtiqurh Branch
B. Bolundshuhur —Do—
C. Koel ——————— Do —

Section I. Works at the Cawnpoor Terminus

The works connected with this section commence at a point 5 Miles 750 feet from the Ganges River near the village of Dubowli; the leading one being an Escape for the purpose of regulating the water on its approach to the Town and Cantonments of Cawnpoor, through which the Canal is carried on its descent to the River. The Dubowli Escape is, in fact, the work by which the Canal supply is regulated on the various Locks, Mills &c of which the Terminal works are composed; and it naturally takes the precedence both from its position, and from the services which it is called upon to perform.-

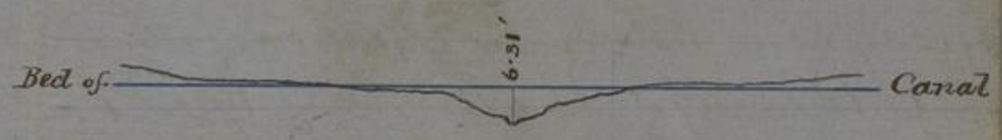
The Dubowli Escape (Plan and Section of which are given in Plate of the XLII Atlas) is situated at a point 11187 feet below the Kujoori Bridge, or that on which the High Road between Cawnpoor and Kalpi crosses the Canal: it is

is built across a tributary of the Pandoo River, which lies 8000 feet on the right, and it combines with its services as an Escape for canal water, a passage for the drainage of the Tributary across which it is carried.-

The Canal Channel at this point is an Aqueduct; the drain=age which is collected from a hollow of about One Square Mile in Extent immediately on the left of the Canal Embankments, passing by arched Channels un=derneath the Canal.-

The Valley or hollow over which the Aqueduct passes is shewn in the following diagram, the horizontal line representing the level on which the bed of the Canal runs, with reference to that of the Nulla.-

Diag: CXXVIII



From its intersection by the Aque=duct to the Pandoo River, the Nulla has a slope of 15·6 feet on a total length of 10000 feet; its course is tortuous, with a deep and nar=row section, which on its junction with the Pandoo, assumes the character of a Ravine; The great depression of the bed of the Pandoo however below that of the flooring of the Sub Channels at the Escape, renders the back water arising from high floods quite harmless in its effects upon the Canal works.

The rain water collected at the head of this line of drain=age

=age is inconsiderable, the Catchment basin lying above the Canal not exceeding as I have supposed one square mile in superficial extent.—

For the passage of the drain=age water collected in the basin, 3 Bays of 6 feet each in width and with a height of 4 feet from the flooring to the Soffit of the arch ~~has~~ have been given on the upstream side; the floorings themselves being built with a rapid slope, so that the discharge outlets on the down stream direction have a height of 6 feet. This slope of 2 feet is on a length of 107 feet, or on the whole width of the building.—

An inspection of the plan will convey a much better idea of the design of this work, than I can give in a written description, it will be sufficient, therefore, to observe, that the Channels above described become the receptacles of the escape water from the Canal on the upper levels, through a series of side openings - 3 of which are situated on each side of the Canal, the total width of Escape waterway thus provided being equal to 36 feet.- These side openings of 6 feet each in width, discharge their water down perpendicular drops which open into the lower chan=nels, the fall and momentum of the fluid being broken by bars of stone placed across the upper part of the drop, and by wells or reservoirs below, which receive in the first instance the body of water, and ease off its action before it proceeds onwards down the bed of the

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the Nulla.-

The Slope which has been given to the waste Channel flowings, and the increased capacity which has been obtained to the Nulla itself, by widening it out from the downstream side of the building, as far as the junction of the Nulla with the Jrandoo, render the Escape both for country and canal drainage purposes very efficient.-

The external faces of this building are flanked by Semicircular Revetments, which on the left bank are surmounted by houses for Store and Choki purposes.-

The Canal Channel which is 20 feet in width has on each side a berm of 10, with a roadway of 20 feet in width, the whole forming a compact body of work; with steps of approach to the water in the Canal Channel.-

I may here observe that the berms which on the whole line of the Canal had been raised 8 feet above the bed of the Canal are from the Kujoori Bridge to the Dubowli Outlet gradually diminished until at the latter work they stand 6 feet above the Canal bed; at this height they continue throughout the whole of the Terminal works which I am now describing - The Canal Channel on its approach to, and departure from the Masonry work of this building, is carried over well made and carefully consolidated Embankments, to which the Semicircular form of wing Revetments is well adapted.-

These

These works are built entirely of Brick masonry with the Cement made of the following proportions

4/5 Rs Runkur Lime
1/5 Rs Sookree —

The quantity of Cubic Feet of Masonry is 48426.

The rates per 100 Cubic feet were Cos Rupees 16.. 6.. 3 and the total cost amounted to

Cos Rs 92[illegible].. 13.. 9

The Dubowli Escape was built by Lieut Rodgson of the Engineers. —

At a distance of 1207 feet below the Escape is the Dubowli Bridge. On the upStream side of this work the Rajbaha Head leading to the line of Irrigation running between the Pandoo and the Ganges is situated (see Plan Plate XLIII)

The Bridge itself is for village purposes, but ~~the use of~~ the works attached to it, ~~is connected with~~ are designed ~~for~~ of Escape as well as for ~~that of~~ Irrigation. Here we have a drop gate which being placed immediately below the Rajbaha Head, and across the Canal Channel acts both for the purposes of regulating the supply of water for Irrigation, or for preventing the onward passage of water towards the Cawnpoor works.. In the latter case the 6 openings at the Dubowli Escape, as well as that for the Rajbaha become the outlets for the waste waters; the Rajbaha playing its part ~~for~~ to any water that may fail in escaping through the six openings at the Dubowli Escape. —

The

Cawnpore

The Rajbuha Head at this Bridge is the last opening for irrigation on the Cawnpore Terminal line, its width is 10 feet and its Sill or flooring is on a level with the Canal bed: the opening, in fact, is so devised that in case of necessity all spare water may pass down the Rajbuha Channel, whilst ~~that of~~ the main line on the down Stream side of the Shutter is laid perfectly dry.-

The design of this bridge is plain, a 20 feet Segment of 60° for the Canal Channel, with side Towing Path passages of 4½ feet in width, flanked by rusticated pilasters ~~with semicircular head or niches in them~~. The width of Roadway is 18 feet, and Steps of communication between the high and low levels are attached to both the up and down Stream wings. The front of the Rajbuha Head, as well as the opposite side of the Channel, are covered as usual with flights of steps, and the full width of the berm is secured by a retaining wall on the same plan as has been designed at the other Bridges. - The Masonry Channel on the upstream side of the bridge, is laid out with reference to the best plan for directing the Current upon the line of Rajbuha.

This work is built of brick Masonry with Cement of the following ingredients

4/5 lbs Kunkur Lime
1/5 lbs Sookee -

The Cubic Contents is as follows:-

2518 lbs Cubic feet

four-fifths
one-fifth

The rate per 100 Cubic feet of Masonry was Company's Rupees 17. 6.. 5 exclusive of Plaster — 4 and the total Cost of the work was Cos Rs 5010.. 1. 7-

The work was built by Lieut Hodgson, the Executive Engineer of the Cawnpoor Terminal line.—

The Dukhapoor Bridge or that for the passage of the Grand Trunk Road between Allahabad and Aligunh, is situated 14176 feet below the Dubowlee Bridge above described. It is similar also in design with exception ~~of Pilasters being rusticated~~; to the width of Towing path passage being 5 instead of 4 feet; and in the latter having Segmental instead of Circular arches.—

This Bridge is built on a Skew at an Angle of 65°, corresponding exactly with that on which the Road and Canal intersect each other. The width of Roadway is 25 feet, and the up and down Stream faces in connection with the Canal Channel are flanked by Semi Circular Revetments adapted to the Towing paths—

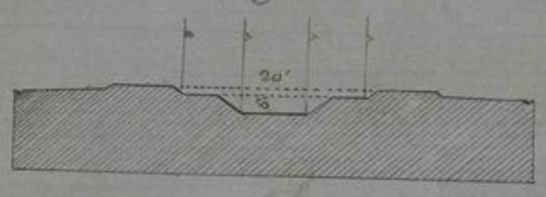
On the whole of the line of Canal upon which the works above described are situated the course has been on a gradual curve, directed upon the boundary separating the City of Cawnpoor from the Military Bazar of the Cantonment. The depth of Excavation varied from 8 to 16 feet and the Soil is good especially on the

Surface

surface, in the immediate neigh-
-borhood of the Dukinapoor bridge
and the Grand Trunk road the
existence for a long period of
Brick kilns, is a proof that the
subsoil atleast is formed of
good brick earth.—

After leaving the Dukinapoor
bridge the Canal runs for a length
of 3764 feet, still on a Curve, through
a good deal of broken ground
arising from the Brick kilns
above mentioned, until it reaches
the angle of the City, at which
the Loading bridge, or No 1, con-
-nected with the series of works
which continue to the Ganges
River, is situated. On the up
stream side of this bridge, the
Channel passed through an ex-
-tensive hollow ~~derived from~~ caused by the
excavation of earth for brickmaking:
here there was a necessity for a good
deal of artificial embankment,
but the soil is good, and the Brick
kilns or native Mazavas which
lie on the right and left of the
line provided an ample supply
of material for all purposes. The
berms as I have before mentioned
are continued at 6 feet in height
from the Canal bed, and the
Section of the Canal from the
Dubowli Escape to the point at
which we have now arrived may
be understood from the following
diagram —

Diag: CXXIX



The Canal from the Head of the

the Terminal works at the Dubowli Escape to this point, passes through an excavated Channel, on a gradual curve, the total length being 19127 feet Forwards and in advance to the Ganges, the length being 7973 feet the Sides are revetted with Masonry, and fitted with the necessary ac-=commodations for giving access to the water, to the Inhabitants of a populous Town. - Up to No 1 Bridge also the line having been carried through open Country, was attended merely by the remission of Revenue for land appropriated; in advance house and garden property had to be obtained by purchase, the width to which was considered necessary for Canal pur-=poses being 280 feet -

The whole of the area occupied by the above Space is situated within the boundaries of the Mili-=tary Cantonment, the householders having no claim to the land, which they held on the usual tenure as Tenants at will; remuneration for ~~it~~ Value of property moveable or immoveable being paid for on the land being required for Government purposes whether Civil or Military -

My Estimate of 1850, for the value of property thus required, was founded on returns submitted by the Executive Engineer, whose data were necessarily imperfect, and who had neither the means nor the power of entering into details - The width of Space was, moreover, under Estimated as well as the ~~Amount~~ extent of building. During the Cold weather of 1850/51, a Com-=mittee which assembled for the purpose

purpose of determining the Amount to be paid for a portion of the land required for immediate operations closed their labors, with a Bill against the Government of Rupees 67167..7..5. The valuation was made very fairly; each house or tenement being measured, and the calculated cost of labor, as well as the probable value of Ma=terial being taken into consideration. The latter item was undoubtedly a high one, and founded on assump=tions which were by me never ex=pected to be realized, nor were they so in the result - Extravagant claims for materials in foundations which did not exist; assertions of undersunk Wells in the proximity of the River, and varieties of de=mands for original expenditure of which there were no external traces, and no proofs of their exist=ence, were received by the Com=mittee with a liberality that, as Director of the works, and, there=fore, as the guardian of the In=terests of the Government, I viewed with some degree of jealousy - The full amount of the claims, however, as recognized by the Committee, were approved of by the Government, and the money has been paid with the exception of small sums for which at present no claimants (strange to say) have come forward -

Hall

In the Cold weather of 1852/53, a second Committee com=pleted the Settlement of the re=maining property that came within the limit of the Canal boundaries

boundaries. This included certain estates or compounds formerly held by Military Officers, which had merged into the possession of natives, and which by lying on the borders of the Canal in the neighborhood of the Locks, were desirable as sites of mills and machinery. The arangements made by this Committee were similar to those of the former one, and the amount of the bill in this case was Rs 22898. 9. 0

It was fortunate that within the area of the ground which it was necessary to occupy, there were only two buildings for religious purposes: One a Mosque (Mussul-=man) and the other a Mundul (Hindoo) The position of these two buildings is shewn in the Map. Both of them have been allowed to remain and although they interupt the alignement of the works, they may be con-=sidered as in no way interfering with their usefulness.

I may observe, that in ad-=dition to the above payments, permission was given to the owners of houses to remove any fixtures for which they had a particular fancy; Carved woodwork, Doors, and all ornamental work, whe-=ther of wood or metal, were not only carefully removed, but given gratis to the original owners.

The Material in fact, which was recovered from the buildings, and which on ~~the completion of~~ their destruction, was carried to the account of the works, was singularly illustrative of my views

on

of its value, as accorded by the Committee. No indications of Material swallowed up in foundations were discovered, the practicity of permanent buildings in the shape of kiln burnt bricks was remarkable even to those who knew that Native bazars and Native buildings consist of wood and grass, and are raised at the smallest possible expenditure of money. With the exception of a very few so called pukka houses which in their detail of construction were generally speaking made of mud faced with brick, the whole of the bazar that came under our clearance, was a mere collection of mud, taken out of holes, which scattered about its neighborhood, afforded harbours for filth and stagnant water, nests of miasma, and reservoirs of offensive abominations.—

It is worthy of record in how far the value of material resulting from actual proof, in its possession and use in the works, tallied with the estimated Amount as paid to the owners by the Government. I shall merely give an abstract of the figures in this place, as I have placed in the Volume of Tables the whole of the detail both in plan and figures by which the Estimate was arrived at

	Estimated Value						True value of Materials		
	Labor		Materials		Total				
1st Committe	20188	1 7	46979	5 10	67167	7 5	8936	12	11
2nd Do.	Both				22898	9 ..			
	Totals Co. Rs				90066	0 5	8936	12	11

All the Bricks that were fit for use, were put into the Canal works, ~~and~~ the full price (and a very high one too) of the Market of the day, ~~was~~ having each paid for them in the above Table. The same may be said of the Timber and other Materials, those which were not required being sold by auction

The total Amount paid for houses and property which fell within the limits of the Canal boundary from the No 1 Bridge, (to which I have before alluded) to the junction of the Canal with the Ganges, i.e. on a total length of 7973 feet, and breadth of 280 feet amounted to Rs 90,061. 0. 5; a sum it must be recollected which is totally independent of the Cost of removal, clearance and pre-paration of the Surface for Canal Excavation.

I have in the 2nd part Chapter II Section III explained my views on the Ganges Canal in its connection with the Town and Cantonments of Cawnpoor, and have shortly described the design of construction of the works, with the plan of Esplanade upon which I place great stress, as one tending much to the appearance of the Canal, and more to the convenience and salubrity of the neighborhood. I shall here enter into greater detail as connected with the buildings themselves, and with the whole of the operations that took place during their construction.

The plan on the opposite page

page is a fair representation of the ground with which the alignment came in Contact. On its

there is a good deal of building besides a considerable surface consisting of either open places belonging to the Cantonment, or cultivated land beyond it. - the whole embracing an area of nearly two Square miles, acts as a Catchment basin which is drained by two well defined Nullas & meeting each other in the Town, and

All the Bricks that were
fit for use, were put into the
Canal works, ~~and~~ the full price

which I place great stress, as one
tending much to the appearance
of the Canal, and more to the
convenience and salubrity of
the neighborhood - I shall here
enter into greater detail as con-
=nected with the buildings them-
=selves, and with the whole of
the operations that took place
during their construction -

The plan on the opposite
page

page is a fair representation of the ground with which the alignment came in Contact. On its approach to the Angle of the ~~City~~ Town upon which it impinges, it passes between the Brick kilns to which I have before alluded, and the Enclosures attached to the Commissariat Department in which the Government Elephants and Camels are kept. This ground is much broken, being intersected by holes excavated for brick earth, which from the length of time during which material of this sort has been ~~made~~ used and carried away assumes at the present day, the character of a series of Lakes rather than holes, receiving as they do, not only the rain that falls upon them but the drainage of extensive areas of land in their vicinity. Through one of the largest of these Lakes, the Canal Channel passes just before it reaches the Elephant Sheds not far from the North angle of which No 1 Bridge is situated

In advance of this point the natural drainage of the Country takes a new direction. A tract of Country which lies on the right of the Canal over which there is a good deal of building besides a considerable surface consisting of either open Places belonging to the Cantonment, or cultivated land beyond it. the whole embracing an area of nearly two Square miles, acts as a Catchment basin which is drained by two well defined Nullas & meeting each other in the ~~City~~ Town, and

and proceeding after their con-
=fluence in a deep Channel which
gradually becomes a formidable
ravine - This Nulla passes the
Church and crossing the Course
(corso) for which there is a bridge
adapted to it, proceeds onwards
(receiving other tributaries) to the
Ganges. -

This Catchment basin is
marked by numerous Tanks or
Ponds, all of which in that part
where the Bazar is situated, are
completely surrounded by huts
and buildings, most offensive
in every way, whilst those on
the open plains although chara-
=terized by a comparative clean-
=liness, are from their want of
well regulated drainage a nui-
=sance. The principal ponds of
the sort alluded to, are figured in
the Map, and it will be observed
that the Canal in its course through
the Bazar passes through two of
them - On all this portion of the
line, therefore, the drainage crosses
the Canal alignement very nearly
at right angles. -

Proceeding onwards on the
line which we have taken up
by the Canal it appears that
a ridge upon which the Musjid
(Mosque) and Serai noted in
the plan are situated lies upon
the water shed of the Church
Nulla, and that the opposite
side of the Slope sheds its water
on a bearing nearly parallel
to this Nulla, but with a direction
corresponding with the Canal
itself - Along this Nulla, in fact,
the Canal Channel is carried on
the

the lower part of its course, and in company with it joins the Ganges at the Gola Ghat.—

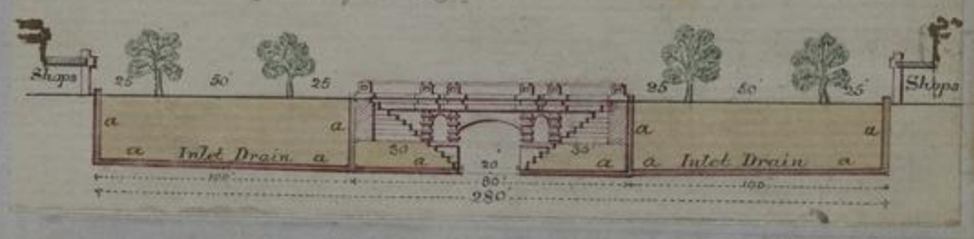
The line of Canal in its passage through the Cantonment of Cawnpoor comes in contact with 2 distinct basins of drain-age both of which will be per-fectly understood from the Map.—

The depth of digging from the point A, or from bridge No 1 up to No 6, or the Course bridge, averages about 12½ feet. On this line which extended over a length of 3766 feet, the flat-ness of the Surface admitted of the works being carried on on One level: the size of excava-tion, however, required for a Channel 12½ feet in depth, with berms and Slopes adapted to the Quality of Soil with which we had to deal would have been inconveniently out of proportion to the width to which our bound-aries were limited; I therefore determined on revetting the whole line with brick retaining walls, by which we should econ-omize Space by relieving the work from Slopes.—

The Section that was deter-mined on was shewn in Diag: XXXVIII Copy of which is for con-venience of reference introduced here.—

Diag: CXXXI

Already Engraved.



The design in fact was an Esplanade

280

280 feet in width, bounded on each side by Façades of Native Bazar, and having the Canal Channel passing down its centre. Bridges of cross communication were to be adapted to the different Streets that had been intersected by the works; and the Spaces on the right and left were to be ornamented by four single lines of Mangoe Trees forming avenues extending on each side of the Canal from No 1 Bridge to the Ganges River.

My idea was that these Avenues with the even and well laid Metalled road or Esplanade on which they were placed, would become the general promenade, and at any rate the lungs and medium for ventilation of the Town in their neighborhood.

I have in the Chapter above alluded to referred to this as well as to the other objects which I contemplated in this line of works: the works themselves however, are the subject of the present Chapter.

From No 1 to No 6 Bridges the ground being even, the works were laid out so that the Esplanades or upper levels should be parallel with the Canal bed i.e. on a Slope of 12 Inches per Mile. between the 2 extreme bridges 4 others were built, each on the plan shewn in sheet XLIV of the atlas.

These six bridges, therefore, divided the whole length of the Channel into 5 separate bays, each of which had its retaining wall

wall in the alignement of the bridge ring pillars, and its Channel fitted with either Ghats (flights of steps) for the convenience of bathers, or with perpendicular revetments or Quays for that of merchandize - The design of these different works will be understood from the plans -

Parallel to the Canal Channel, and in lines one of which rests on the extreme Canal boundaries, and the other on the back of the retaining walls of the berm, are a series of drains or Bombas, dropping vertically into Masonry Channels, which are constructed at right angles to the Canal. - These drains are built in positions suitable to the wants of the neighborhood and it is supposed that they will give efficient drainage to all the Town, Bazar, and land requiring it. The principle on which these drop drains are arranged with reference to carrying off the water from the high levels to those of the Canal Channel is shewn in the above diagram a. a. a. a.

The dimensions of the different bridges and bays as mentioned above are as follows:-

A	No 1.	Bridge	Feet	23
		Bay	"	573
B	. 2	Bridge	"	23
		Bay	"	626
C	. 3	Bridge	"	23
		Bay	"	587½
D	. 4	Bridge	"	23
		Bay	"	1215
E	. 5	Bridge	"	23
		Bay	"	672½
F	. 6	Bridge	"	33
Total Length from Upstream side of Bridge A No 1. to the down stream side of Bridge F No 6.				3822½ Feet

Two miles

/

On the left of the Bay and corresponding with the lower branch of the Church Nulla an outlet with 2 openings of six ft. wide each has been constructed for the purpose of giving relief on the occasion of heavy floods as well as of acting at a convenient spot as a regulator for the supply of water upon the Heads of the locks.- This outlet is carried under the Esplanade by Masonry Channels which pass off the water down the Church Nulla. - Sluice gates for the purpose of regulating this Escape are arranged at its head; they are on the simple construction adopted elsewhere -

The Bridge F No 6, which is built for the accommodation of the Course (Corso) road is ~~built~~ on a Skew with an angle of 55½° conformable to that at which the road crosses the Canal -

Up to this point the evenness of the surface of the ground admitted of the works being built, not only on an almost direct line, but with their upper and lower levels corresponding - From the Course bridge, a new order of things commences, the ground falls off in considerable slopes and at a point 515½ feet from the downstream side of the bridge, the drop of the 1st Lock is situated.- Although the same system of parallel revetted lines for both the Channel and Esplanades is continued, the irregularity of the upper surface necessitates a declination to the Esplanades,

so

so that whilst the Canal here con-
-tinues on its uniform slope of
12 Inches per mile, the esplanades
or Surface of the Embankments are
carried on in a succession of slopes
corresponding with the drops at
which the different Locks are situ-
-ated. - On this line, moreover, the
direction to which we were limited
forced upon us the necessity of
continuing the curve, so that on
standing on the No 6 Bridge we
lose the perspective which a direct
bearing upon the Gauges would
have given us; an effect which
would have been of material ad-
-vantage to the look of the works.

From No 6 Bridge, therefore,
the esplanade and its retaining
wall slope downwards on an
incline of 13½' to 100' for a length
of 267 feet, at which point it
meets the horizontal level upon
which the lock buildings are
constructed. The distance between
the foot of the inclined plane
and the upstream face of the
Bridge which crosses the lock
Chambers is equal to 368½ feet,
and it is proposed that this
flat should be used as a landing
place for goods on boats having
reached the higher levels. In
the immediate neighborhood
of No 6 Bridge, flights of steps
are built for communication
between the high levels and the
berm, and close upon the heads
of the lock Chambers are side
Channels for the supply of Mills
which are situated on the right
and left, beyond the limit ~~of~~
the

~~the right and left beyond the limit~~ of the 280 feet boundary
The waste or Escape Channels
of these Mills enter the Canal
below the bridge and at a point
free from the influence of lock-
-age.—

This Bridge which is called
No 7 **G** corresponds with one of
the Main Cantonments roads,
it is built at right angles to
and over the Lock Chambers,
and has a roadway of 30 feet
its total width between the up and down stream Parapets being 33 feet
in width; (vide Plate XLIV, Atlas)

At this place I may describe
the locks; as although in the de-
-tail of fixing and working the
Gates; in the Plan and arange-
-ment for the regulating Sluices;
and in the general dimensions
of the Chambers, they correspond
closely with those which have
been built on the Main Trunk
and which I have fully described
in a former chapter; there are
some differences in the lining
out and general detail that
are ~~is~~ deserving of explanation.—

In the first place I required
an ascending and descending
series, so that boats might pass
up from the Ganges, at the same
time that others passed down.— I
considered it to be a great advan-
-tage, that even supposing ~~that~~ the
Ganges Canal was not available
for Navigation, the means of raising
loaded boats from the low levels
at which the River runs, to the
higher, where the Town and Can
-tonment are situated would
be a great boon to the commercial
Community

J. Dawson

community, and per se a very great advantage. Such arrangements might be made by properly economizing the water so that even in drought when Irrigation carried off the greater part of the supply, a sufficient Quantity of water would be available for purposes of the soil required, and although, after all lifting boats by common water Locks is but a clumsy arrangement, and in all cases a very slow one; it is a very great improvement upon the existing method of unloading boats on the lower levels, and carrying the Goods on Carts, or mens shoulders to the higher.-

Again, not only to effect this purpose, but to give full means for regulating the supply at the Head of the Locks by apparatus fixed in the Lock itself; it was desirable to design waste Channels independent of the Chambers, and in such a compact form that the object might be gained at the smallest possible outlay.-

It will be seen, therefore, that the Centrical wall separating the ascending and descending Lock Chambers, is perforated on its whole length with a Channel 6 feet in width, fitted at its head with regulating apparatus. Into this Channel the low level Chamber Sluices with their circular drum regulators, discharge the surplus water, which passes off at the outlet at the lower end of the wall.—

The

The drop at each of the Locks is 9 feet with a reservoir of 15 feet in depth at its foot; in front and at a distance of 7 feet from the drop, a timber apron for the purposes elsewhere described separates the drop from the main body of the chamber which is 112 feet long inclusive of the lower gates. The width of the chambers is 16 feet. The details of fixing and Collars is pre-cisely the same as that car-ried into Effect on the Main Trunk.—

From the down stream face of No 7 G, or No 1 Lock Bridge, a recurrence of a similar arrange-ment to that last described de-liners the Esplanade on No 8 H bridge; the Canal bed continuing on its uniform slope of 12 Inches per Mile whilst the tops of the banks, for a distance of 285 feet 4 Inches are on an incline of 1½' in 100 feet. The total distance between the down stream face of the upper, and the upstream face of the lower bridge being 1543½ feet.

No 8 Bridge H passes the Main Street of the Cantonment over the Canal, its width of road way between the plinths of the parapets is 30 feet, and its total width between its two faces is 33 feet. This Main Street road has been much improved by the interposition of the present bridge the elevation of which above the original levels relieves the road from an awkward depression which originally existed and which was one of the great dis-

disfigurements of the main Street To effect this a good deal of earthwork was necessary in forming the approaches, and some masonry in securing effective drainage.

At this point the Canal is partly in the Ravine or line of drainage as shewn by the maps, and as it will be observed by studying the Longitudinal Profile of the land with which it is connected, is mixed up with a quantity of broken and irregular ground, which required a great deal of artificial em-=bankment, and much care and judgment in laying it out. Great attention on the part of the Engineer in Executive charge was required in disposing of the drainage water not only during the progress of the works but in so adjusting the inlets that the water might be ad-=mitted in sufficient quantities to relieve the Country, and at the same time by such grad-=ual means that neither the Canal works nor the country itself should be injured. This was most satisfactorily accom-=plished by Lieut Hodgson. The greater portion of the drainage water which fed the Ravine being turned off in a Southerly direction as shewn in diagram CXXX

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Part iii Ch viii

From

From the down stream face of No 8 Bridge H to the head of the drop of the next Lock, the distance is 852 feet; the Canal bed being continued on a slope of 12 Inches per Mile. At the point where this descent takes place, the fall is considerable, and it is disposed of by 2 Locks in succession, each having a fall of 9 feet. The design of these works being similar to those before described needs no ~~description~~ further illustration. At their tail however, No 9 Bridge I is thrown across the Chambers in the same way as it is done in the cases before described, affording convenient cross communication to the bazars and houses in the neighborhood.

The plan of overcoming the depression of the Country on this line is effected in the same way as was described in the approach to No 1 Lock. The Esplanade is carried on an inclined plane from the down Stream face of No 8 bridge on a slope of 1 foot in 100 feet to a point 631 feet below it: from whence the esplanade continues horizontal up to the head of No 3 Lock, from which point another inclined plane on a slope of 7½' in 100 feet delivers the esplanade on the level of the road-way of No 9 bridge which as I have before said crosses the tail of the Lock Chambers. The flats at the head of the Locks are intended for the accommodation

=dation of loading and unload=
=ing merchandize. —

Between these two Bridges No 8 and No 9 we were in con=tact with the old Ravine, and on the downstream side of, and close to the former a deep hollow extending for 153 feet, with its bottom 12·2 feet below the Canal bed had to be filled in, and the foundations of the revetments had to be carried to a proportional depth; on the approach to the head of the Locks, a good deal of ground had to be cut away, to bring the esplanade on an uniform level. The whole of the ground in fact was a series of ups and downs, hills and hollows requiring much care and pains in its adjustment.

At the Head of the Locks No 2 and No 3, arrangements have been made by constructing outlet heads, for establishing Mills or Machinery, should such be hereafter desired. —

The country drainage is on this line managed in the same way as it was before, and as is fully detailed in the sheets of maps. —

We are now rapidly descending to the edge of the water of the Ganges, although (as I have before described as a peculiarity ~~attending upon~~ in the immediate vicinity of the river) getting amongst elevated mounds which, low as the level is com=paratively with that which we passed in our progress thro' the Doab, is high with reference

to

to the uniform Series of descent by which the Canal works are gaining the lower levels. Thro' these Mounds cutting to a considerable extent was required especially in advance of the works which I have just described

From the down Stream face of No 9 Bridge, the Esplanades are sloped downwards, until they meet the horizontal levels which continue up to the Terminal buildings. These slopes have a base of 282 3/4 to 9' in height and the length of the flat in front is equal to 503 3/4 feet, measuring from the foot of the slope to the extreme point in the Curve of the Semicircular ends. On this line No 4 and 5 Locks are situated, each with a drop of 9 feet, placed in close proximity to each other as in the case of No 2 and 3, and in dimensions and design precisely similar.

On this line there is no Masonry bridge across the Chambers in consequence of the position of the Flood levels of the Ganges during the rains, which it will be observed by reference to Fig: 2 Sheet 5 Plate XLIV Stood 13 inches above the Sill of No 4 Lock.

I have in Part II Chapter II when reviewing the works on the Cawnpore Terminal line described the architectural features of the Terminus on its Ganges Face, shewing how I have attempted to plan these buildings, in harmony with others

others which scattered along the
edge of a richly wooded bank
are so characteristic of River +
Scenery as connected with Towns
and Cities on the Ganges and Jumna
The Lock Chambers are flanked
by Semicircular Ghats or flights
of Steps, reached from the higher
levels by stairs opening laterally
from the higher levels of the Es=
=planade. These lateral stairs
are broken by a landing place
which gives the steps a direction
to the front, and delivers them on
the upper tenace of the semicir=
=cular Ghats. On the right and
left of these steps and standing
well above the tenace are prides=
=tals for the reception of Sculpture
emblematical of the Ganges River.
Nunda's Cow, which is one of
the best of the Hindoo conceptions
in the way of Sculpture, being
a Cow in repose although with
its head erect, is the emblem that
I proposed for these Pedestals; its
face would be towards the Stream

On the flanks of each
of the Semicircular Ghats, are
Octagonal Pavilions consisting
of Domes supported on pillars
Each flank, therefore, of the Lock
Chambers, is ornamented by 2
Pavilions with their intermediate
flights of Steps, those of approach
to the front Stair case being +
flanked by the Sculptured +
figures before alluded to.

The State of the Ganges
River during high and low
water will be understood from
Fig: 2 Sheet 5 Plate XLIV of the Atlas
The extremes as shewn in this
Sheet

Sheet being 15·16 feet - During high floods, therefore, the lower or No 5 Lock would be entirely thrown out of use; Nos also would only require the use of the Gates for loaded boats on their draw- -ing more than 13 inches; and for descending craft; the volume of water passing down the Canal, would Supposing it were 4 feet in depth, reach the high levels of the Ganges on a rapid which would ren- -der the use of the No 4 and 5 Locks unnecessary —

On the upper levels to the works just described and on the flat below the No 9 Bridge, houses for Machinery might be erected; water power, however, at this point would vary with the rise and fall of the Ganges, and during the rainy Months when the Surface of the River arrived at its maxi- -mum, it would be either im- -paired or stopped altogether. Mills and other Machinery, therefore, ought to be placed on the levels on and above which No 9 Bridge is situated. - On all that upper line, the back water from the Main River would have no influence —

From the above description with the plans before him, the reader will be able to comprehend the design of these works through their whole length viz. from No 1 Bridge where the continuous Masonry works commence to their junction with the Ganges River - The total length is 7973 feet, 3822 feet of which has its

its Esplanades on a level parallel with that of the Canal bed, and the remainder which includes the whole line through which lockage is carried, is in a succession of Slopes and flats corresponding with the natural descent into the River —

As a general rule the superficial soil to a depth of 6 to 10 feet was found to be a very tenacious quality, below which it was more or less sandy, in some places of unmixed sand. — The foundations were laid in without any interruption from Spring water, and were consequently of simple construction, and in unbroken lines of wall. The whole of the works have been built of brick Masonry, generally Speaking with 12" x 6" x 3" bricks, burnt in the neighboring Kilns, although the small native brick has been largely used, not only from the ruins of the old buildings that were purchased, but also from the Pazawas or native Kilns: — good and well burnt bricks, in fact were taken without reference to their size, although the larger class was preferred, and was more generally brought into use —

I have devoted a Sheet of the Atlas to the design for the foundations of the River front which as coming in contact with a lighter Soil, and being directly in connection with the Main River, requires peculiar care and attention. On the face of this plan my working directions to the Engineer in

in charge of the works, will sufficiently explain the nature of the formations with which we had to deal. The superstructure it will be observed is founded on a series of blocks, undersunk in the way that has been elsewhere described. These blocks are carried to a depth of 12 feet, varying however, with the nature of the soil that was met with in the course of undersinking In front of the whole work and facing the river a protective apron of piles and heavy material has been given similar to that which has been adopted wherever Masonry work is in contact with a Stream or Current, ~~has been given~~ as shewn in Fig: 1 Sheet 5 Plate XLIV of the Atlas —

Left for Atlas

Hobbs Dawson

The rates at which the Brick Masonry was executed on this line of works averaged pr 100 Cubic feet Cos Rs 14.. 14.. 1 the extremes being

Rs 19. 10. 8 for Arch work
" 14. 1. 10 for Other kinds

the difference depended on the species of work that was executed —

From No 1 to No 4 bridges on the upper line, with a portion of the intervening Revetments were done under the management of Lieutt C.lo. Hutchinson who in the first instance had charge of the works — The Cement which was used at this time consisted of about 2 equal parts of Kunkur Lime and Bajree — the rate of Masonry being pr 1000 Cubic Feet Cos Rs 14.. 9. 10

Lieut Hodgson who succeeded the above mentioned Officer, and under whom the greater portion of the work was done, by having the lime burnt upon the works, and by putting a stop to the purchase of ready made lime from Contractors, introduced an improved material, which in my Opinion has led to superior Masonry — Lieut Hodgson's ingredients for Cement were as follows:

3/7ths Kunkur Lime
1/7th Sookee
3/7ths Bajree —

and his rate pr 100 Cubic Feet of Masonry was Cos Rs Rupees 14.. 14.. 6 —

The rate for underpinning the blocks is shewn below:—

Ths

the work, however, was in progress at the period of my leaving India, and the data, therefore, which I have given is consequently imperfect in so far that it does not include the general averages of contingent expenses, which can only be made up on the completion of the work.

Cost of underpinning Masonry Blocks at the Cawnpoor Terminus Cos Rs 7. 2. 0 per running foot.

Section II. Terminal Works on the Etawah Line.

None of these works had been commenced upon at the period of my departure 1854. and as I have ~~alluded to~~ said in a former chapter, I would recommend their postponement until a future date, when the supply of water and its effects upon the Cawnpoor Terminus are better understood than they are at present. There can be no use in hurrying to completion works which cannot ~~possibly~~ in all probability be required for many years to come. I would, therefore, collect all the imperishable materials e.g. Kunkur and bricks necessary to carry on the buildings with vigor, when Lockage into the Jumna was desired, but as the progress of the works now going on

on, on the Etawah Line, will not for a period of 2 years be advanced to the point where the Terminal works are to be built, there is plenty of time both for consideration as to the period of their construction, as well as to their design - Of the latter, therefore, I shall content myself with giving the general views I hold on the subject, leaving the detail to my successor, who will be better able than I am to determine a plan for buildings appropriate to the desired object -

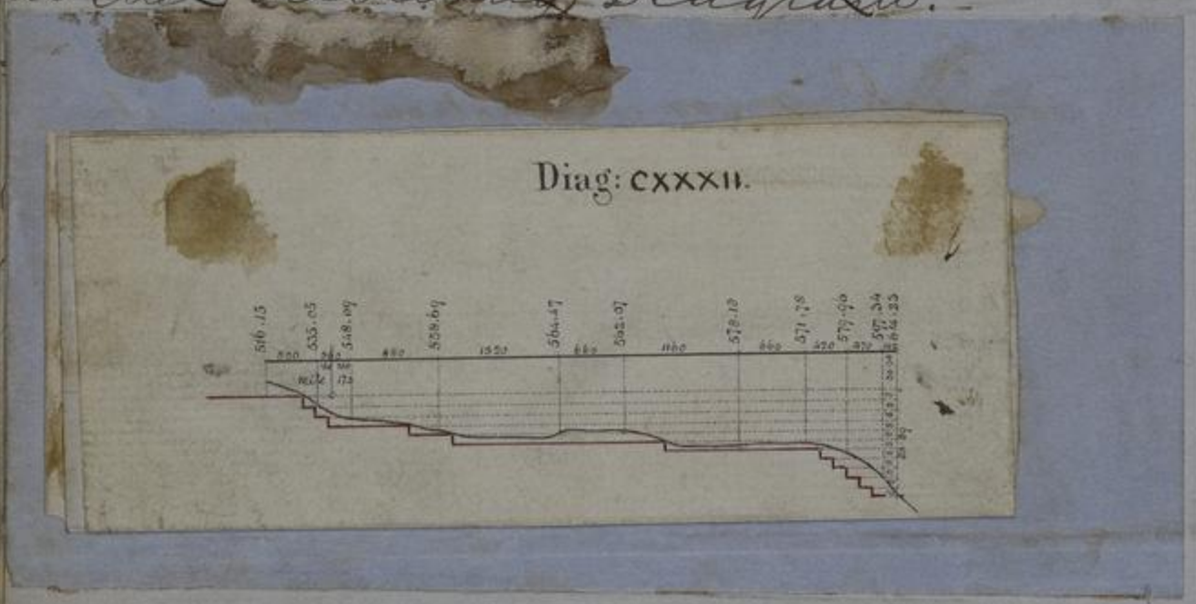
There are two points on which the Cawnpoor and Etawah Termini differ very materially, and both of them are of great importance in any design that is projected - 1st The Cawnpoor Terminus is in the midst of a Town, through which the Canal Channel passes, on a length of 7973 feet, before it reaches the River - 2nd The Slope into the Ganges at Cawnpoor is comparatively abrupt, the locks being at no great distance from each other, and all of them in a compact and regular series The Etawah Terminus into the Jumna on the Contrary, is on an Open Country separated altogether from Towns or Villages; and the high bank or commencement of the descent from the high to the low levels is situated at a distance of 1/4 mile from the bed of the Jumna the stream of which at the period I am writing runs on the Bundelkhund or opposite side of the valley, leaving a long tract of intermediate low ground between

between the 1st Descent down which lockage will be required, and that by which access will be gained to the River itself. — Here, therefore, will be a long & straggling line of works instead of a compact series of buildings as is the case on the Ganges, and here, also, a less expensive design will be more appropriate. It must nevertheless be kept in mind, that, if the supply of water in the Canal is sufficient to afford water for navigation as well as for Irrigation: and if there is sufficient water in the Canal to keep a constantly running supply upon the locks, these buildings will inevitably become the nucleus of a Town, and the seat of a manufacturing population, based upon the water power which is available on the high levels upon which these works are situated. Altho' therefore, there may be no necessity for going into heavy expenses in Sluts, Mills, &c, &c, in the first instance; we ought to hold these things in contemplation, and to anticipate a period when if wanted they might be built in conformity with a comprehensive design of which the present works ought to be the nucleus.

Under this view of the Question, therefore, I would retain the Plan of the ascending and descending Series, or of the double line of Chambers as has been built at Cawnpoor; I would also adopt the method of

of waste and Escape Channels therein practised, but I would limit the extent of Revetments, and be satisfied ~~in the first instance to as much as possible~~ with Earthen Slopes, ~~and at~~ thereby ~~through~~ leaving full scope for ~~all these~~ improvements ~~hereafter~~, afterwards ~~I would in the first instance have nothing to say to them.~~

My Plan would be as follows, working upon the Section of the Country as shewn in the following Diagram.-



The above Diagram exhibits in Section the slope of Country in connection with the descent in approaching the Lumma River. There will be four steps separated by Reaches varying from 600 to 2000 feet in length; the design for the upper 3 steps together with that of the Terminal Escape into the River with a understood from Plan in the Atlas which represents this Detail the whole of that work ~~the intermediate~~ for passing these steps is understood from the Atlas which represents in detail the terminal reach of Lock which delivers the Canal water into the Jumna River.

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Return
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Section III. Termini of the Branches

A. Futtigurh Branch. This is a work which is altogether prospective: it has been fully explained in Part II Chapter III see page 525
At present the Branch is strictly for Irrigation and it terminates at the 160th Mile of its course, in an escape which throws the tail water into a line of natural drainage The distance from the terminating point above noted to the Ganges River at Futtigunh is 21 Miles and as the total fall may be considered as equal to 41½ feet, a series of lockage as I have proposed viz: 4 drops of 8 feet each with an intermediate slope of 5¼ Inches per Mile, so as to provide a moderate scour to the Channel, would connect this Branch with the Town of Futtigunh as well as with the Ganges River, which runs immediately below it. I have entered fully into this subject, however, in the Chapter before referred to.

B and C. The Bolundshuhur and Koil Branches, the former after passing through 80 miles of Country and the latter through 50, form a junction at a point not far from the Town of Hatrass From thence they proceed onwards in one united Stream under the name of the "Hatrass line of "Irrigation" through the country lying between the Seyngoor and the Jumna Rivers. This line terminates in the Ravines on the Seyngoor River, or it may be carried over these Ravines and form a junction with the Etawah

Terminal

Terminal on its approach to the Jumna. It is supposed, however, that at such extreme points (excepting during the rains, there will be no water sufficient to render permanent works necessary a point which experience only can decide.

I have when describing the Bolundshuhur branch alluded to the possibility of a navigable line being taken from that Branch to the Jumna passing by the Town of Belaspoor. This line would join the Jumna immediately below the confluence of the Hindun River, and might be convenient as opening out a line of traffic from a Country richly cultivated to a River which although not capable of carrying heavy craft during the dry months of the year, holds sufficient water for the easy passage of such boats as would pass down the Canal: it would in fact connect the Bolundshuhur and the districts in its immediate neighborhood with Delhi, Agra and the Towns lying on the banks of the Jumna.

Hall

CHAPTER, IX.

Solani Aqueduct

I shall consider the works on the Solani River which ~~are discussed in constitute the head of~~ this Chapter as divided into three sections

I. Earthen ~~Aqueduct~~ Portion, Revetted, with Terminal works for the passage of ~~connected with~~ the Solani valley

II. Masonry ~~Aqueduct~~ Portion for ~~the passage of meeted with~~ the Solani Torrent.

III. Bunds and Embankments on the Solani River & itself in connection with the Aqueduct.

I have in the early part of this paper explained the position that the Solani River holds with reference to the drainage of that portion of the Ganges Khadir with which the Canal works are connected. It is in extent of catchment basin dependent on our works for escape by far the largest of all the Torrents; the slope of bed, however in contact with these works is comparatively moderate, but it meets us in a region of sand. The area of the basin lying above the works is equal to 216 Square Miles, its length may be estimated at 27, and its average breadth at 8 Miles.

of

of this area 50 Square Miles lie in the Sewalik Hills, the remainder on rapid but gradually decreas=ing slopes until it reaches the Ganges Canal Works where the fall in the bed of the River is 5·08 feet per Mile

The Topographical charac=ter of this Basin is ~~a mere~~ exactly the same as that of the Basins of the ~~Upper Doons of those which have~~ ~~been before described as attendant~~ ~~upon~~ other mountain Torrents connected with the Sewaliks already described. In the Hills themselves the tributaries and water Channels that ~~pour~~ their supply into the main branches are distributed on courses so ^ marvellously tortuous, and over ground so curiously entangled with Ravines, that without visiting the top of one of the high Peaks which are scattered along the ridge, it is hardly possible to appreciate the nature of the drainage, or to estimate the amount of area connected with these Torrents ~~which lead the Hills~~. The aspect of the ^ Sewaliks as viewed from an elevated point, is that of an extensive Plateau, broken up by an intangled reticulation of fissures or Ravines, the con=tinuity of any single line being to the eye untraceable from the inextricable confusion that appears to exist. True position of Watershed can under such circumstances hardly be defined, and that above given which is taken from the Revenue Map must only be considered

as

as the best approximation. The Solani valley lies on the extreme west, and ~~bordered on~~ skirts the Bangar or Highland of the Doab on its whole course to the Ganges. Its heads are on the watershed which divides the basin of the Jumna from that of the Ganges. The water that is shed on the western side comes in contact with the Eastern Jumna Canal works, as connected with the Muskura; that on the Eastern flows towards the Solani Aque-duct. —

The Muskura as I have formerly mentioned, has great advantages in its elevated position with regard to the general drainage of the high land over which it passes. These advan-tages have been ~~clearly discerned taken possession of~~, and used largely in directing the Torrent on lines bearing away from the Canal works, by which the River itself on its coming in contact with the Dam at Kulsea is reduced to manage-able proportions. —

The Solani, on the contrary, which has a hill front equal to 12 Miles., plunges at once in-to lowland, and one of its main branches which debouches from the well known Pass called the Kheeri or Lal Durwaza, (through which is a road from the Plains to Mussoori and Landour) forms its junction with the Main Stream that proceeds onwards under the name of the Solani, just below the Town of Kheeri and the high

high road from Sahaunpoor to the Hills. At this point the high land which forms the Eastern border and along the western foot of which the Solani River runs, is 18 feet higher than the bed of the River; a command which is increased on its arrival at Roorkee or at the site of the Aqueduct to 41 feet. There appears, therefore, to be a bar to any diminution of the volume of the Solani River by throwing it upon other lines as has been done in the case of the Muskurra. The heads of the West Kalli Nudee which lie to the West of Roorkee and Bhugwanpoor appear to be the only available hollows for such a purpose, and their relative levels are opposed to it. It has, therefore, been considered as a matter not to be disputed that the Solani River has to be dealt with in ~~all~~ its integrity, and that as in the case of the Rutmoo and Puttri Torrents, we have no other resource than to meet each other by mutual accommodation. Without loading this paper with registers of floods the following diagrams ~~will~~ shewing two of the highest on record since the year 1810, will give a tolerable idea of the extent of the Solani, and the amount of inundation dependant upon it during the rains.

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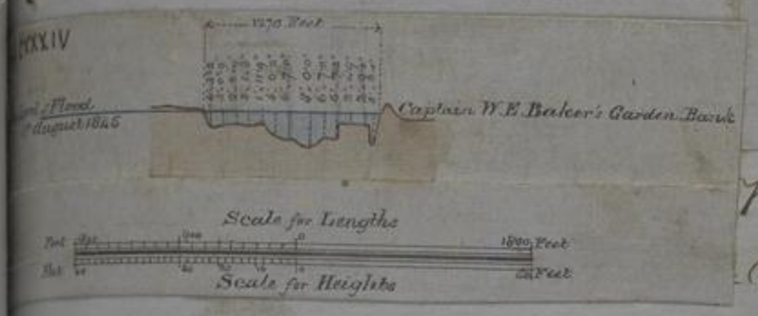
Dias. CXXXIII



The line on which the above Section was taken, is perpendicular to the Stream and was selected during the height of the flood of the 5th August 1845. The above area appeared to be occupied by running water, the velocity of which was not measured, but was estimated not to exceed an Average of 5 feet per Second.

		Area of Section	Assumed mean Velocity	Discharge per Second	Waterway of proposed Aqueduct up to level of Flow	Calculated Efflux
		Square feet.	Inches	Cubic feet	Square Feet	feet
Highest flood	1845	3695	60 4	28475	6000	None
Do	1844	7014	68·8	40190	6750 b	0·02405

Both these floods occurred previously to the commencement of the aqueduct works, and before obstruction in any form had been placed in the way of the water. The value of the calculations may be estimated by the remarks appended to the Diagrams. The Section of 1844, was taken somewhat obliquely to the course of the River, and in both cases, the calculated discharge I believe to be in excess to ~~that of~~ the true one.—

The Valley or Khadir through which the branches running from the Hills pass up to their confluence below the Doon of Kheeri, is almost entirely Forest, of that order which is peculiar to the Southern foot of the Sewaliks, composed in a great measure of Kyr (Acacia Catechu) with ~~the~~ low growing Shrubs, dotted here and there with Bur, Peepul, and other gigantic Trees, which, however, are remarkable from their scarcity.— The land in the immediate neighborhood of the Hills is shingly and more or less marked by boulders obtained from the degradation of the Superstrata of the Sewaliks which consist of Shingle beds; on the lower tract it is clay and sand, much inter-

intersected by lines of drainage
The Boulder and Shingle cease
before the branches reach Kheeri

Below this junction, or
below the confluence of the
different branches which are
connected with the Sewaliks,
the Solani runs in a straggling
course between the high iso-
-lated mound which separates
it from the Rutmoo, and the
elevated land on the right;
at some points it shews a
well defined section through
clay of a very tenacious quality,
at others and generally speaking,
it wanders about on a tortuous
course through the low land
or Khadir which ~~during geological periods~~
~~has formed for itself~~
~~it has formed for itself~~; here the bed is
universally sand, although
in the few cases where the River
runs in a confined channel
the banks and bed are of clay
A very good section of the latter
description will be found at
a distance of 8500 feet from
the upstream side of the Aque-
-duct, where the River during
its highest floods appears to
pass through a well defined
channel, without lateral in-
-undation of any sort. At
the site of the works the course
of the River was tortuous, with
a sandy bed depressed about
40 feet below the surface of the
valley, which on its whole ex-
-tent below Kheeri is more or
less cultivated with wheat and
other cold weather crops.—

It will be understood
that

that the high land bordering on the Solani Valley between Kheri and Roorkee throws a considerable quantity of drain=age water into the Valley, this is effected on the right by well rounded off ravines, some of them extending a Mile into the Country, and connected with land of very undulating char=acter. On the left or from the isolated high land which I have called the Peeran Kulleem ridge, the same species of drain=age takes place varied, however by two lines of considerable im=portance as exhibiting col=lective drainage, the one be=tween the Towns of Sukrowda and Imli, the other rising near the village of Goomawdla; the former was one of the im=pediments that offered itself to the circuitous line which was the alternative in crossing the Solani Valley; the latter, which I have called the Imli Nulla, as it passes to the East of that Town, joins the main Torent at a point about 7200 feet # above the Aqueduct. I may observe that in estimating the value of the Catchment basin I have included one mile in width of the high land lying on the right, and the whole or nearly the whole of the Peeran Kulleem ridge which lies on the left of the Solani Valley, as ground which sheds its water into the Solani River

A Peculiarity which is an attendant feature on all

these

these Khadir Rivers when ~~where are~~ bounded by high banks, viz^t: the existence of Nullas parallel to and close under the banks themselves, is here, as elsewhere, remarkably prominent: they + exist both under Roorkee, and under the villages of Mahewun and Bajoohera; or those lying on the right and left of the Valley. They are crossed at its intersection by the Aqueduct.—

In the Chapter devoted to the Dams, in which the detail of the Rutmoo River and its works is given, I have explained that the line of Canal on its change of direction at those works, proceeds on a direct bearing through the Peeran Kulleem Ridge to Roorkee; this bearing is 218:36°, it is unbroken, the axis of the Regulating Bridge at the Rutmoo or Dhlunowra works, and that of the Roorkee Bridge which is situated at the downstream Terminus of the Aqueduct being one.—

The Surface level of the Country on the line now taken up by the Aqueduct is shewn in the longitudinal Section or Profile Plate LXIV of the Atlas. The ~~Valley is the valley first~~ alignment touches ~~approached~~ between the two villages of Mahewun and + Bajoohera, and reaches the opposite side close upon the East of the Town of Roorkee. The width of this Valley between the Points where the true bed of the Canal intersects the high banks on its right and left

Graham

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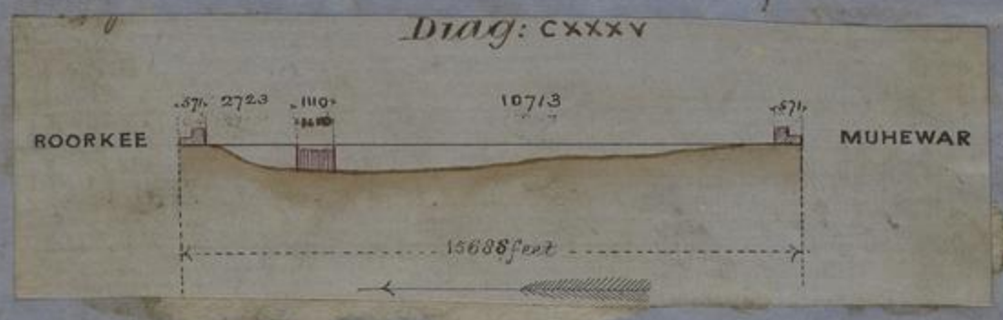
left is equal to 13265 feet or a little more than 2½ Miles. its maximum depression be=low the canal bed is 24, and that below the Surface of the Country is 41 feet.

The Aqueduct consists of a Masonry Channel carried over the Solani Torrent on a series of 15 Arches of 50 feet Span each This Masonry Channel is con=nected to the high land at Roorkee and Muhewar by an Earthen Channel flanked by Revetments built in the Ghat or Step fashion; these Revetments are backed by wide Embankments the upper sur=face of which is 30 feet in width with exterior Slopes of 1½ to 1. — The Earthwork both of the Canal bed, which from the above ex=planation it will be under=stood is considerably raised above the Valley, and the Em=bankments on each side are made with great care and well Consolidated. —

The Longitudinal dimensions of the works on this River will be understood from the following Diagram. —

Diag: CXXXV



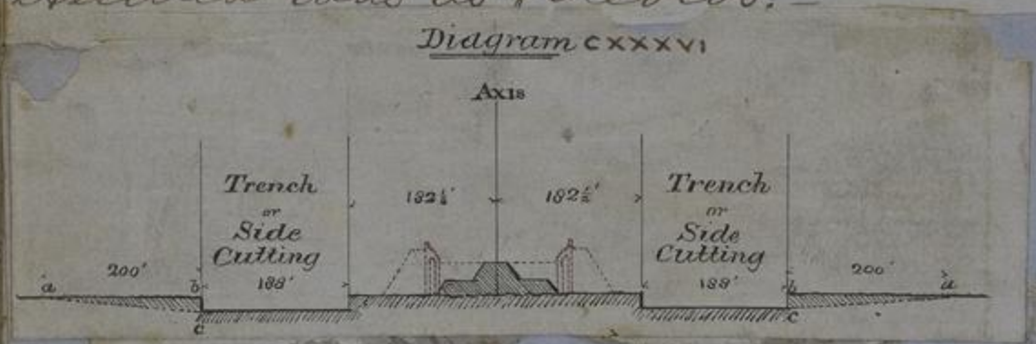
With these Prefatory remarks in which will explain the general character of the River, as well as the nature of the work which has been

been designed to ~~give~~ effect its passage, I may take up the details seriatim, commencing with

Section I. Earthen Aqueduct ~~Revetted~~ with Masonry Revetments and Terminal Works &c.

This was the first portion of the Aqueduct works which was undertaken. The commencement was made in the Cold weather of 1845/46 on the left bank of the Solani River, and in low ground between it and Mahewar The work at this period consisted of excavating trenches on the right and left of the Aqueduct line, and throwing the Earth on the Centre, so as to form a Nucleus for the raised Embankment which was to constitute the bed of the Canal on that portion situated between the Revetments. The lining out upon which this work was executed was as follows.—

Diagram CXXXVI



The trenches were 188 feet in width and carried to a depth of 5¼ feet the earth being placed in contact with the axis line above shewn, and in ~~such a manner~~ that it should not interfere with the building of the Revetments, the lining out of which was not perfected until the beginning of 1848. The Earth obtained by the means

means above described, although by no means inconsiderable in amount, was small when compared with that required; it provided however a good foundation upon which superstructure might afterwards be raised, the earth itself as taken from the surface was tolerably good, and in 1848, on my rejoining the works, I found the whole in a very satisfactory state of consolidation.

At the same time that the work above explained was in progress, the Canal Channel at Roorkee was going on; here a commencement was made on the edge of the high land, and the earth was carried out into the valley by wheelbarrows moving from a high to a lower level on a continuous line of planks, the distance to which the earth was carried by these means being from 2 to 300 yards, and the labourers who were employed being able bodied men receiving as monthly pay 4 Rupees. Major Baker who at the period that I am now describing was directing the progress of the works, in writing to the Military Board on the 22nd August 1846 observes; that the work above alluded to, may be considered to have been executed under favorable circumstances and "yet the rate of Earthwork "averaged from 3 to 5 Rupees "per 1000 cubic feet, increasing "rapidly with the distance to "which the earth was conveyed."

Major

Major Baker in pointing out the necessity for using Rails and Wagons on the Northern side of the Aqueduct or that near Mukewar, and shewing that the whole of the Earth beyond that already excavated in the Side Cuttings, must be brought from the Canal Channel Excavation in the Peeran Kulleeur Ridge; recommended that my Agency should be employed for the dispatch from England of the Iron work required for a certain number of Wagons, and that no time should be lost in the arangements which had been formerly proposed of obtaining from England the services of Artificers, and men practically acquainted with Timber and Iron work. As early therefore, as 1816, preparations had been made for supplying the works with means of transporting earth from the distant Cuttings. In the meantime, however, the progress of the works was delayed by a variety of circumstances which have been detailed in the first part of this report, and although nothing was carried on with vigor until very shortly before my return to India, I found on my arival at Roorkee, a considerable number of Wagons ready for use, with much preparatory information on the economical practice, and construction of Tram or Railroads as adapted to the particular duties for which we required them. My duties therefore were comparatively

-tively easy, and confined it may be said to working out the design, and carrying out such improvements as experience shewed to be necessary.—

Wilkshire

On my returning to Roorkee and relieving Major Baker from the Directorship, the State of the works may be thus described. The trenches on the left or North of the Aqueduct were very nearly completed, and the earth was placed in position as shewn in Diagram CXXXVI, a temporary or Service Bridge had been thrown over the Nulla or line of drainage which I have described as skirting the valley on the Mahewun side, and which was intersected by the Aqueduct Embankments, the object of this Bridge being to afford a passage or means of communication on the level of the valley, for Carts and Laborers, and on the higher levels for the Ballast wagons when carrying earth; the Bridge was situated on the axis of the Aqueduct as figured in the above Diagram.—

On the Right or Roorkee bank of the Solani a portion of the Side Revetments had been completed on a line of 100 feet and a considerable portion of foundations and Archwork had been done and was in progress in the vicinity of the completed portion; Earth had also been excavated, and carried as I have above described in Wheelbarrows to the Space between the Revet-ment Walls.—Lieut. Yule who at

at that period was Executive Engineer in charge of the works at Roorkee was also engaged in laying out the alignement of the Side revetments between Roorkee and Muhewar; a work requiring great Skill and careful observation, the direct line upon which the walls were to be carried being upwards of 2½ Miles in length.

Captain Goodwyn who relieved Lieut Yule on the 15th April 1818, and Mr Finn who a short time previously to my return in January had been appointed to the Material Department, commenced at this period to organize a System of Railways connected with the Brick Manufactories which had been established at Roorkee and Muhewar, that is to say, at each end of the Aqueduct. The Railways were necessarily a main feature in the earthen Aqueduct, as it was through their aid that the Embankments would be formed. The first part of our operations, therefore, consisted in laying out the Brick fields in an uniform shape, with lines of rail running parallel and close to the Kilns; these formed branch or 2nd Class Lines, which were connected with the 1st Class, laid along the axis of the main Canal. The former were single, the latter double lines of Railway. The brainches were confined entirely to the carriage of Bricks or Material from the Manufactories; the

the Main line was for transporting Earth from the Channel to the Em=bankments which in viaduct fashion were pushed forward into the Valley, the railways being ex=tended at their termini, in propor=tion as the work on the Excavation and the Embankment advanced in progress.—

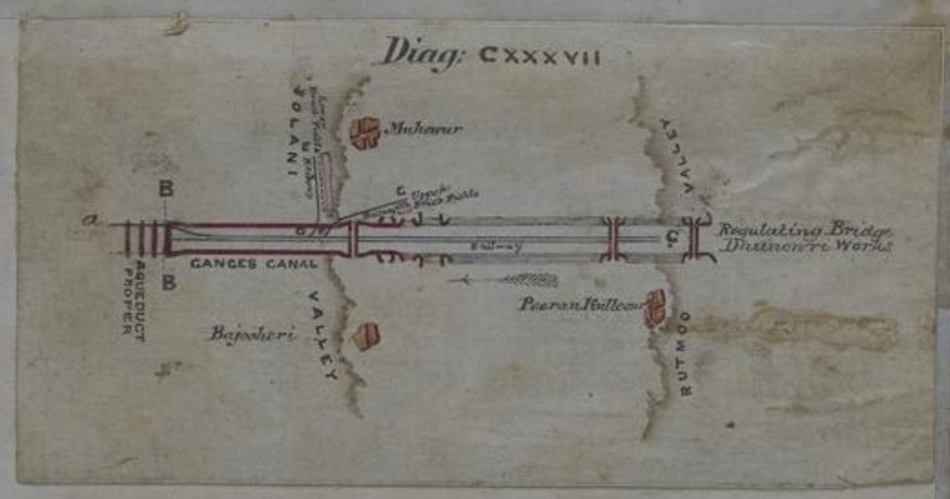
On the Left or Mahewun side the direction of the Slope of the Railway corresponded with that of the Canal and the natural flow of the water. A commence=ment to the Railroad therefore was made at a point near Mahewun; the line was carried on a Slope of 1:5 per Mile centri=cally on the Canal Channel and Earth excavated from the Peeran Kulleeun Ridge was pushed out, and the line progressively ad=vanced until it reached the Solani River, or the point where the Earthwork terminated on the Masonry Aqueduct; The gra=dient of the Rail was 3 Inches in excess of that of the true bed of the Canal, and consequently obtained at its extreme terminus a depression below that of the true bed level.— With this Main Centrical Line, two branches were connected, one leading to Brick fields and Lime Warehouses & which were situated on the high ground, the other to the great Brick Manufactories under the Mahewa Village and on the Slope of the bank bordering on the Valley. The former, 2050 feet in length, was obtained by some

some moderately deep cutting, and was brought upon the Main line by a Curve of 300 feet radius on a gradient of 1 foot in 133 feet. The other was a heavier work, as it had to be carried from the Canal bed on rather a high level, over some very low ground lying on the outside of the Embankments. Over this piece of low ground a temporary Bridge was constructed and the Railway which was carried over it on rather a sharp curve was pushed forward on an Em= =bankment raised to a mean height of 20 feet from the ground, and in a direction parallel to and at a distance of 100 feet from the line of Brick Kilns. - By this arrangement, or although we had more difficulty in loading the Wagons, we avoided the greater difficulty of a steep incline, and by the rail being elevated there was no in= =terruption to communications. foot passages being made through the Embankment and under the Rail at fixed distances along the whole line. - From the sharp= =ness of the Curve at the point where the railroad crossed the Service Bridge, it was found necessary to raise the bars on the Concave or outer side 3 Inches above those of the inner. The length of this line was 2500 feet on a gradient of 1 in 250. -

The direction of the Railroads on the Malewan side will be understood from the following diagram. -

Diag: V

Diag: CXXXVII



References	Distance
BC Main Line extending from Left Abutment of the Aqueduct, through the Peeran Kulleear Ridge to the Rutmoo Valley	20853 Feet
DE Branch Line to Lower Brick fields	2500 "
FG —— Do —— Upper —— Do ——	2050 "
a Muhewar Material Line across Aqueduct Cut waters	1120

On the Right or Roorkee Side, after completing the flooring and foundation of the Bridge a similar line of rail road was laid down from the Bridge towards the Valley. As the direction of the required gradient was opposed to that of the Canal bed Slope, the position of the rails at the Bridge was raised so that the road when it came in contact with the Masonry Aqueduct or the point where the Earthwork terminates, might coincide in level with with that particular point. This can be best described by a diagram representing the different lines of rail as connected with the Roorkee side, during the process of the Works.

Diag: CXXXVIII

AH. Main Line for Carriage of Earth	6355
KA' a Branch Line for the Carriage of Materials extending across Cut Waters of Aqueduct and meeting the Muhewar Material Line; distance from K to A'	5567 6700
KL	1330
LA'	3037
KL1 Brick field Branch	1380

The gradient of the brick kiln line on K A' a North of the Roorkee bridge was 1 in 208, South 1 in 200. That of the Excavation line H. A. was 1.25 feet per mile.—

The above although some what anticipating events when describing our early operations will shew how the Railroads gradually got into proper form; the Earth or Main line A H which is continued on one uniform gradient, so as to deliver the Earth on the highest levels required for the bed, stood during our early progress on a very elevated position; whereas its parallel line A' L which was specifically designed for the Carriage of bricks from the Kilns to the works was depressed so that at the point A' it touched the levels of the Cut water heads of the Aqueduct proper, along which it was carried, ultimately across the River, and joined on to a branch taken from the Main trunk line on the Mukewar side of the Embankments. As the work advanced in progress, therefore, the Termini of the Aqueduct, and the works at Mukewar and Roorkee became connected; a bond that was more closely

d on the completion of the
ches of the Aqueduct proper
en the Main Trunk was car-
ied across, forming a line
railway from Peeran Kuleem
to the Roorkee kil

The first rail that was laid down consisted of bars of flat iron, varying from ½ to

3½ inches in thickness, screwed upon longitudinal sleepers, which were held in position by cross bars or transoms, these in fact, with certain modifications and improvements in ballasting, scantling of wood used, and method of fixing the bar upon the sleeper have been used very successfully throughout the whole of the operations; they were subject to a good deal of wear, and were more difficult to retain in position, than the English rail which was intro=duced in 1850, but they did their duty efficiently, had the merit of cheapness, and of being easily replaced by purchase from the neighbouring markets. In 1850 however, 30000 running feet of light rail bars, which had been selected in England by major Baker, arrived at the works; they were of that variety denom=inated bridge rails weighing 26 ttos to the Yard and the method by which they were fixed on the woodwork was much the same as that adopted in the flat Iron, that is to say in longitudi=nal sleepers with cross bars; at this period, however, we had found it necessary to give additional thickness and massiveness to the sleepers and woodwork in general, and the ballasting was made of a better and more expensive species of material; the superiority of the rail over the bar was sufficiently recog=nized by me in the procuring of a further supply of the same

sort

sort as that first received, giving us a total length of 60,000 running feet, which with the tram road, supplied us with all that was required both for the works at Roorkee and Dhunowri.

As the whole of the Earth-work connected with these Rail-roads naturally fell into the cost of Embankments and was included in their expenses, it is difficult to give a precise return of the actual cost per Mile of the different Species of roads made upon these works. On both the Roorkee and Muhewan double lines where flat Iron bar was used the cost of Iron, Timber, with all the necessary apparatus for fixing, including labor employed up to the period when the wagons were placed upon them was as follows:-

Muhewan Main Line Double Railway	Co Rs	18974..12..8
Roorkee do do	"	18760..12..2

The work at each place was carried on ~~under~~ separate European Super-vision, and the accounts as rendered to the Executive Engineer of the works were quite indepen-dent of each other; the returns on the 2 lines correspond so closely that they may be looked upon as fair rates of this Species of railroad Here, however it is distinctly ex-plained that as far as Earth work is concerned, the above rates merely include the consolidation of the earth; ~~the~~ Excavation, carriage and laying out of the said earth, as well as of the Ballasting being charged to the Em-

Embankments, of which it forms a component part. - The above rates appear to be verified in a great measure by the cost of single railway at Roorkee where there was no Embanking, but where the Sleepers were laid on the earth with little or no artificial ballasting further than was required to maintain the woodwork in position and to keep the rails steady. A mile of single rail laid down under the above circumstances cost Rupees 8809.. 9.. 4; the work was required for wagons which were during the whole of the working day passing backwards and forwards loaded with bricks, and although clearly inadequate to permanent work was quite sufficient for the purposes for which we wanted it.

Saxon

The Cost of railroad where English rail was used varied very little from that above described, with exception to the cost of the Iron. - This in the case of the Flat bar as purchased from the markets was delivered at Roorkee at a cost varying from Rs 1700 to Rs 2100 per mile of single line; whereas the English rail when it reached Roorkee stood us in Rs 2575 for an amount equal in extent to the above distance.

The wear upon the wheels and flanges was greater in the case of the flat bar than in the English rail, the surface friction of the former being not only much greater, but much more

more uneven. I can compare the difference of motion in travelling over lines made of flat bar Iron and the bridge rails which have been used on these works to nothing better than that of unmetalled and metalled roads; comparatively speaking they bear the same value to each other; the wheel in one case running awkwardly and with constant jerks, whilst in the latter or English rail, it passes on evenly and steadily. —

Plans and Sections of the different railroads with the wood and Iron work connected with them, will be found in Plate XXVII of the Atlas. —

Previously to my reaching Roorkee a number of Small wagons had been made up with side doors and without tilting apparatus, these gave us the early means of commencing our earth carrying operations. I had, however, brought with me from England, tracings of what I thought to be the ~~xxxx~~ wagon best adapted to our works with the Iron work of one wagon complete; a wagon therefore on this plan was immediately placed upon the work, its tilt was to the rear, similar to those which during my residence in England I had seen universally employed on railroads; and which were convenient from throwing the Earth forward in pushing on Embankment across a valley. This rear

Tilt

tilt however, did not appear to be applicable in our case, the Embankments in England are made little more than the width of the Sleepers on which the rails are laid, the rear tilt therefore, throws the Earth in the position in which the Railway Engineer requires it. In the Rock=Kee works after the line of Rail=road was completed, the rear tilt became useless as we required a wagon that would empty the earth on the right and left of the line, from whence it could be spread out on an extended surface, which the form of the Aqueduct rendered indispensable The Rear was, therefore, changed into a Side tilting wagon upon which plan the whole of our carriages was ultimately made up.— I have in Plate XXVII of the Atlas given drawings of all the wagons that have been used Sheet 20 Figs 1 and 3, or that which was made first of all is cheap and as far as first cost went, the most econ=omical; its want of tilt and the small quantity of Earth that it carried weighed strongly against its further adoption; this species of Cart, therefore, was discontinued, after those which had been originally made up were worn out. The only modi=fication that the Cart in question required was the Prolongation of the Side downways to a point (vide Figs. 2 and 4. Plate 20) beyond the wheels, so that in unloading the Cart, the Earth might not interfere with the rails

rails - Before this alteration was made, the earth on the opening of the side door fell upon the rail directly between the wheels, thereby preventing the movement of the wagon, and causing interruption to the passage. -

The cost of one of these wagons including the wheels and Axles which were received from Calcutta was Rs 289..9..5

Plate XXVII Sheet 21 A or the Ballast wagon, the plan of which I brought from England, has as I have before said a rear tilt and in other respects as well as this, is ~~common~~ similar to those of English railways - For the reasons above given only two on this plan were made up, they did their duty well, but as I have before explained they were not ~~applica~~ well adapted to the work - The cost of each was Rs 138..1..3

Plate XXVII A Sheet No 22 Is the standard plan upon which all the wagons in general use have been made, it has a side & tilt, is very strongly put together and carries a load equal to 50 Cubic feet: - Of these 450 have been employed either on the works at Roorkee, or ~~=~~ those on the Rutmoo River at Dhurmpore - The cost of each averaged Rs 358..0..4

Having explained, therefore, the lining out and design upon which the Embankments were to be made, and having described the material at our disposal for carrying on the operations

operations of the Earthen Aqueduct, I shall now proceed with a detail of progress, from the commence=ment to the completion of the work as made by Mr James Parker the Assistant Engineer who was placed on this Specific duty under Capt^n. Goodwyn.-

The State of the Earthwork on the commencement of progress by railroad at the beginning of 1848 will be understood by a reference to Diag: CXXXVI and to a former paragraph in which I have mentioned that independently of the Side Cuttings figured in the Diagram alluded to, and which were confined to the Mukewan Side of the Valley, earth had been thrown out from the Channel Excavations on the Rookee Side. This work having become well consolidated, acted as the Nucleus for Mr Parker's railways which were started in the first instance from Mukewan.- At this place as far back as 1846 accommodation in the shape of a Chokie building had been constructed for European Superviso=rs, and other necessary cover, for Lime, workshop purposes, and ultimately stabling was completed at different subse=quent periods. The duties of the Engineer at this point ~~was~~ included ~~entitled to~~ Masonry as connected with the Side Revetments, and Terminal Works; as well as ~~in~~ Earthwork in raising the bed of the Canal, constructing the embankments in rear of the Revetments, and (as the Earth

F. 10

For this purpose was taken from the Canal Channel on the line between Muhewair and Peeran Kulleem) in completing the Canal as far back as the Rutmoo valley

The general design of the Aqueduct will be understood from the plans in the Atlas. Its total length from One extremity to the other is 15688 feet, independ=ently of the Masonry Escapses at=tached to the upstream terminus which having been constructed for purposes which in all proba=bility may never be required, and which are in fact imbedded in the Imbankments, are not in=cluded in the above measurements

These Escapses which con=sist of a Masonry flooring 100 feet in width placed on a level 12 inches below that of the Canal bed, with flank walls, are in immediate contact with the upstream Terminal ends of the Aqueduct; they lie on both sides of the Canal, and are in con=nection with a hollow or Ravine, which in the description of my original Survey, was shewn to cross the line of Canal at this point. This Ravine was the outlet of the Burrumpoor Nulla, which commencing in the high land on the West, terminated in the Solani Valley under the Village of Bajoohee im=mediately on the East of the Canal. The Nulla was dis=posed of by a Cut carried to the west of Muhewar, so as to turn its flood water into the Valley

before

before it reached the canal boundaries. The topographical character of the ground at this point will be best explained by a Diagram in which the upstream terminus of the Aqueduct is introduced.-

Diag: CXXXIX

Here A.B represents the Canal Channel intersecting the Burrumpoor Nulla at C; a' b' shews the Cut that has been made to remedy the interference with the drainage caused by the Canal Embankments

and to pass the flood water of the Burrumpoor Nulla into the Solani valley west of the village of Mahewar. At the point C the Escapes which I have alluded to above are situated; they rest it will be observed on the end of the Aqueduct buildings with which they are in contact.-

The following diagram will shew the object of these works, which are merely protected passages to be made use of on extreme emergency; they are in no way connected with regulating supply, or with the relief from superfluous water under ordinary circumstances; they are in fact safety valves in the event of serious injury to the line of works in the valley,

to

to be used only as a last resource, when every other remedy fails: It will be understood, moreover, that they are filled in with earth and excepting from the protrusion of the flank walls on the Canal front are concealed from sight. They would be brought into operation by working parties who would remove the earth sufficiently to give a passage to the current. —

Diag CXL.

The above Diagram which represents the works connected with the Rutmoo and Solani Torrents, will show that by closing the Regulator or Stop Bridge at A and by opening the Sluices of the Dam lying across the Rutmoo River, the whole of the Canal supply is turned off. The Canal Channel below the Regulator is laid dry, and the water passes down the Rutmoo. —

The distance between the Stop bridge at A and the Up-Stream Terminus of the Solani Aqueduct, and the two Escapes lying in contact with it at C is exactly 14629 feet. The Channel on this distance being on a

rectangular

Commun

15161 distance from axis of Regulator
Terminus
To axis of Stop Bridge from axis of
is carried for
from 15161

rectangular section of 140 feet in width with additional side slopes on a depth of 12 feet equal to 1½ to 1.- Supposing, therefore, that a serious accident was to occur on the line of Aqueduct, which rendered an instantaneous riddance of water necessary, the remedy would lie in closing the Stop bridge at Rutmoo, by which all further access of supply would be stopped.- Assuming an extreme case in which at the time the Regulator was closed, there was a depth of 10 feet of water in the Canal; the Quantity of water which it would be necessary to get rid of before the Channel at the point C was laid dry would be equal to an amount 14629' × 1500 = 21943500 Cubic Feet ~~all of which~~ independently of that standing on the Aqueduct Channel at the time ~~would have to be got rid of~~.- It was under this view of the question that I determined on providing the means of relieving the Channel from as much of this water as was possible by making the Escapes at C.- It is by no means improbable that a more efficient remedy may be invented for getting rid of the earth which now fills these Escapes than that which I propose; the Permanent Establishment of Laborers, which will be maintained for the repair, clearance and maintenance of the Embankments and their slopes, will always, however, be at hand

hand, and as the cutting of
Embankments on emergency
is not an uncommon expedient
in dangerous floods, it is possi-
-ble that the present arangement
will answer. — I have an objection
to Permanent Works for regulating
the Supply being built either
near the Aqueduct or at this
particular Spot: Such works
when built on a country like
that of the Khadir lead to marsh
and quicksand with rank
vegetation on the tail line of
Escape; — they would be particu-
-larly open to objection from this
circumstance alone, as regards
the health of the neighboring
Country; but the proximity
of the means of Regulating
supply offered by the Rutmoo
renders further Works, intended
for this purpose merely, quite
unnecessary. — The Escapes at C
are either useful on emergency or
they ought not to have been built
at all. — I have after mature de-
-liberation built them, they at least
offer an alternative which with-
-out them would not exist. —

From what has been said
before, it will be understood that
the Embankments are carried
over the Escapes above described,
so that the Slopes of the Canal
Channel impinge upon the
Terminal Works of the Aqueduct

The Termini consist of a
Circular Quay or Bastion 30 feet
in diameter, raised to a height
of 12 feet or to that of the Berm
or Towing Path; this form of
structure admits of the junction
of the Earthen Channel with that
of

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of the Masonry, under more con-
=venient circumstances than any
other shape; and in the present
case, the extent of diameter when
compared with that of the slopes
and berms of the Earthen Channel,
affords a security against the
effects of the Current. These bastions
are surmounted by Pedestals, bear-
=ing upon them Effigies of the
existing Asiatic Lion, recumbent
with their heads erect, and look-
=ing outwards from the Aqueduct,
~~both~~ or upstream on the upper,
and down stream on the lower
Terminus.

To the bastions on the Aque
=duct side a line of Ghats or
flight of Steps from the berm
level to the water is carried for
a distance of 75 feet until it
meets the Cattle Ghats which are
inclined planes extending from
the rear of the Embankments
to the water, for the purpose of
giving access to Cattle for drink
=ing purposes. This inclined
plane which is 50 feet in width
is crossed by 5 flat Masonry
Arches of 17 feet in Span so
as to keep up the line of com-
=munication along the berm
Each flank of the Cattle Ghat
is protected by a wall termin
=ated by an Octagon Tower, or
as has been described in the
Chapter under the head of bridges
by what the natives term a
Bytuk or place for sitting upon
From the Cattle Ghats, flights
of steps, like those that are
in Contact with the Terminal
bastions approach the Bridge
in the form of an Ogee grad-
=ually

=ually expanding from a width
of 150 to ~~that of~~ 179 feet. These
steps come in direct contact with
the face of the Bridge which con-
=sists of 3 arches of 55 feet Span
each, with piers of 7 feet; ~~the~~ it
comes under Class No 1 of the
Bridges described in a former
Chapter. The Bridge roadway
being elevated to a height of
24 feet whilst that of the berm
is only 12; the former is gained
by a ramp with a slope of
3.668 in a hundred, the ramp
towards the berm being covered
by a retaining wall which
terminates at the foot of the
slope and at the commencement
of the ogee. The Bridge road
=way which is horizontal has
a width between the plinths
of the parapets equal to 17½ feet
and the approaches from the
Country are on a slope of 2
in a hundred.—

The Terminal works
including the Bridge and
measuring from the extremities
are 571 feet in length. The de-
=tail is the same on both the
up and down stream Termini,
and the Bridges the former
at Bhuhewar, and the latter
at Roorkee are in every res-
=pect as far as superstructure
is concerned identical.—

From the Bridges that
constitute the lines of Terminal
communication, the Earthen
Aqueduct across the valley may
be said to commence; The
Revetments which are on one-
=cisely

=cisely the same scale and shape as those before described, leaving the bridge in a corresponding ogee, and proceed onwards in direct parallel lines, until they come in contact with the Aque=duct Proper, or masonry work under which the Torrent of the Solani River is carried. To meet this work the extreme width of which between its flanks is 172 feet, these Revetments again expand into ogee curves, the extent of expansion being from 150 to 172 feet.

The total length of the re=vetted Channel on the upstream side is 10713 feet. On its down stream it is 2723 feet. The transverse section is shewn in the following diagram.

Diag: CXLI.

Diag: CXLI

The design of the Revetments as originally planned and figured in my report of 1875, has been (I believe in consequence of my anticipation of the discovery of Kunkur in great abundance in the neighborhood, not having been realized; and from a desire to reduce the amount of masonry) considerably modified both in principle and construction; and although comparatively speaking only a small portion had been done previously to my rejoining the

the works in 1848, the reasons for making the alteration appeared to me sufficient to prevent my returning to the old model. By shewing in Diagram Sections of the Revetments as originally designed, as modified, and as afterwards improved, this part of the work will be perfectly understood. —

Diag CXLII

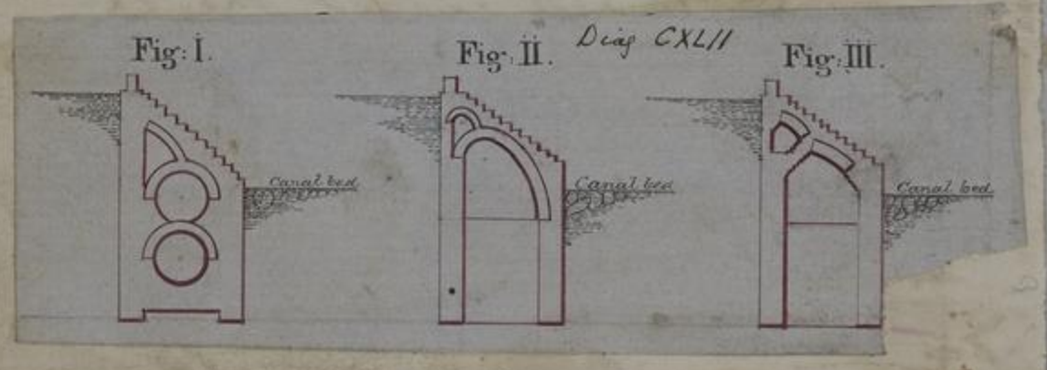


Fig: I Shews the original design, the principle of which was that the Revetment should as far as stability was concerned, be entirely independent of the pressure of the Earth either from the Embankments on the outside, or from the Canal on the inside. The carrying out of this design however depended on the resources in Rubble and brick; its cubic content was considerable. —

Fig: II Modified design.
The front and rear walls were tied together by a transom or cross wall at every 15 feet, this cross wall extending to a height of * feet. In this Section the decrease of Masonry over that in Fig: I was very great. Its stability, however, depended on the Earthwork, and on the contingencies of thrust arising from the Earth both on the Canal and Embankment sides. Consequences arising from this which occurred during the rains of 1848 led me to improve the section, or rather I should say to modify it still further, by attempting to obtain a more satisfactory equilibrium of the parts than it had at that time. It was difficult to do this without falling back into the Evil of increasing the Cubic content, an evil which ~~Fig: II~~ the above design had got rid of. —

Fig: III Shews the remedy that was applied in the above case, it increases the cubic Content but decreases the amount of Arch work, and in principle it relieves the back wall from a portion of the thrust that exists ~~in consequence~~ in Fig: II, by throwing the

* Note. The height varies that of the Revetment. The wall being in all cases carried to the height of the Springing of the arch

the weight more forward, and by dividing the action both of weight and thrust more equably throughout the mass

Stahar

With exception to those portions of this Revetment which were built previously to the year 1819, the whole have been constructed on the design figured in the 3rd Section. They have been built almost entirely of brick, the exceptions being on the Mukewan side, where Kunkur as far as that material could be procured was used; and on the Roorkee side, where a considerable portion of the walls has been built of vitrified masses from the kilns. (Nat: Tamur) have been used in Masonry wherever they were available, although they have chiefly been turned to account in the ballasting of the railways.

These vitrified masses

In addition to the Revetments which face the Embankments on the sides of the Channel, the exterior slopes are at each thousand feet of their length accommodated with flights of Steps, 4 feet in width for the purpose of facilitating the communication between the high and low levels; the height of these flights of steps varies with the distance from the side of the Valley, those which are in the closest approximation to the Aqueduct proper, or to the Channel of the Solani River being from the Terreplein to the top of the Embankment 31½ feet. this in fact conveys an idea of the variety of heights to which the Section figured in Diag

CXLI is subject. From the Terminal Bridges where the surface of the earth and top of Embankment are on one level, the height or depth of Revetment gradually increases, until its arrival at the Aqueduct Proper on the Mahewar side it is equal to 37¼ feet, and on the Roorkee side 36¾ feet. The exterior slope steps which I have above alluded to are confined entirely to the Mahewar line of Embankment, that on the Roorkee side being provided on the left with conveniences of the same description at the extreme ends which are in contact with the Aqueduct Proper and the workshops: On the right, with steps at the Aqueduct end only.—

Reverting to Diag: CXLI which represents a section of the Revetted Aqueduct in its completed form; the progress of construction will be understood from the following diagram

Diag: CXLIII.

The deep shade in the centre of the Canal bed represents the Embankment which was pushed forward from Roorkee and Mahewar to support the rail road. In correspondence with the advance of this road, earth was brought for filling in to the right and left or up to the level

Diag." CXLIII

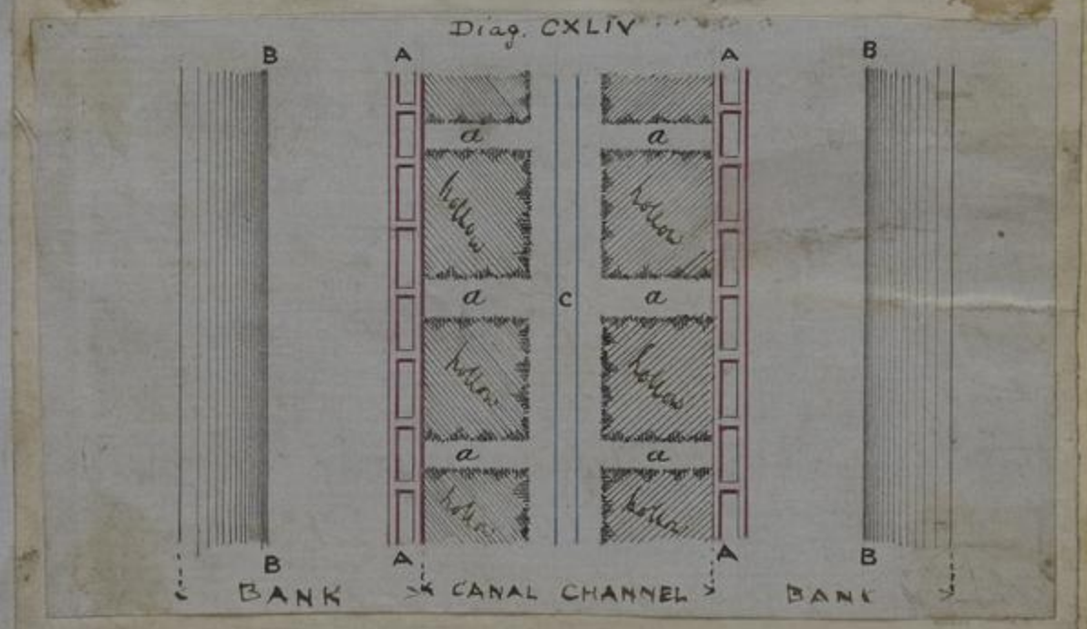
Note for the printer

C. Position of wagon for filling above canal bed

D. Position of Wagon for filling in up to the level of Canal bed

level of BB; this was done in the method described below, its pro=gress was continued through a period of 5 years, and its object was to obtain by a suc=cession of rainy seasons passing over it, the utmost extent of consolidation to the Earthwork

Diag. CXLIV



Diag: CXLIV Exhibits a ground plan of the Revetments AAAA on either side of the centrical line of railroad C, the lateral plants a.a.a.a. being roads raised to a level with the railroad, for the purpose of carrying the Earth to the Embankments in rear of the Revetments, or as far back as the lines BB, BB. The spaces between the lateral roads a.a.a.a. which left the line of rail at every 200 feet, and which are Shewn in the diagram by shade, were left hollow, so as to act as reservoirs for receiving water during the rains; they acted as ponds for the purpose of distributing moisture by absorp=tion, and by these means of gaining consolidation by ac=tual Settlement. During the whole of the period when this was going on, the Embankments

in

in rear of the Revetments as well as the Spaces in the Revetments themselves were in progress up to the level of BB Diagram CXLIII, Early during the season of 1832, and as the works became more advanced, the ponds or reservoirs above described were filled in, and work was commenced on the Section above the level of BB as shewn by the dots. The plan adopted here was a mere repetition of what had been done in the Canal Channel on the lower levels, that is to say, lines of rails on both banks were started from Mukewas on the higher levels, and earth from the Peeran Kulleem ridge was brought forward to complete the works. At this period of our operations a good deal of earth was obtained for completing the banks and their Slopes, by excavations from the outer limit of the Side Cuttings as shewn in Diagram CXXXVI where the triangle a, b, c, was removed and the earth excavated therefrom was thrown upon the Embankments. By this plan we not only obtained Earth at a comparatively cheap rate, but we equalized the Surface of the ground which in the neighborhood of the Side Cuttings had by weathering and by the action of rain water become very irregular. On the Roorkee side, local circumstances prevented an arrangement of this sort, in that case the earth was carried from the rail by inclined planes towards the higher levels, and the whole of the Embankments were completed without the aid of additional railroads

I may observe that even on the Mahlwar side, inclined planes of the sort used near Roorkee were practised with great advan=tage to expediting the forming of the rear Embankments, here, however, this was the exception, on the Roorkee side it was the general rule. The accidents that took place during the progress of this work were limited entirely to slight disarangements of the Revetments. These happened during the rains, either by col=lected water passing round unfinished portions of walls, or as in the case of Fig: II Diag: CXLII by the rear wall being acted upon by the thrust of the Arch; in these cases an irregular disposition of earth led to disarangement, but nothing of a serious charac=ter occurred; I believe that with the exception of the results of a heavy fall of rain that occured in 1850, when a number of the lateral roads a, a, a, figured in Diag: CXLIV failed, by which the collected water from a ~~Reservoir~~ Succession of Reservoirs forced its way along a line of Revetment and knocked down the unfinished end of it; all the disarangements, slight as they are, which have taken place have arisen entirely from unequal distribution of the earth in connection with the walls. In cases where the Revet=ment has been enveloped both inside and out with earth equally distributed, the walls have not suffered in the slight=est degree.

The way in which the

Earth

Earth was carried, the species of draft used, and the rates per 1000 Cubic feet of work executed in the Earthen Embankments became a very interesting part of the history of the Aqueduct. It will be recollected that in the early stages wheelbarrows and daily basket labor, were the means by which a good deal of the main body of the Embankment was formed; the introduction of rail roads and wagons relieved us from wheelbarrows and baskets, but for a long time kept us with men both for excavation and for propelling the wagons; as time advanced, horses in some measure took the place of men, and on the 22nd December 1837, we started a Locomotive which I believe to have been the first Engine of the sort that was ever used in India. We, therefore, went through all the grades of Carriage, with varied results, all of which however, appeared to be dependant on local causes, or economical arrangements with regard to time. Our Methods of working, therefore, were:—

1st With Baskets and Wheelbarrows
2nd With Earth wagons propelled by Men
3rd With Do Do propelled by Horses
4th With Do Do by Locomotive

With regard to the 1st it is unnecessary to lay any particular stress: further, than that it led to the introduction of a very efficient species of barrow which is figured in Plate XXVII of the Atlas; and that in using the barrow a leather shoulder Strap was

was distributed for the purpose of giving relief to the muscles of the arm; an introduction which was adopted with unlooked for celerity by the Laborers themselves who now consider the Strap as a necessary part of the Wheel barrow. This circumstance trifling as it may appear, is so far a matter of interest that it shews how ready the native of India is to renounce old habits, and adopt new inventions if he practically comprehends a reason for doing so. The Wheel barrow after all however, is entirely European, and is so little understood by the native of India, that instances have been known, of their having been sent out to Excavators, and used by them as baskets, i.e. filling them with earth and carrying them bodily on their heads!!

The 2nd Item where the Earth wagon is propelled by men was for a long while the only method used on these works; it has even up to the last been largely practised, and taking the extraordinary cheapness of human labor into account, it may after all be the cheapest. In estimating the value of labor, however, in a large work like that of the Aqueduct, we must look to time as well as to facilities for procuring laborers; the use of cattle, supplies the place of men when such are either to be procured with difficulty, or when they may be more economically employed elsewhere, and in this respect they possess a

a value independent entirely of the actual cost of their employment.—

I have before stated that the wagon in use on these works is of a side tilt pattern, it carries from 45 to 50 cubic feet of earth or from 30 to 33 cwt.. When men were used in propelling these wagons, 4 Bilders or Excavators were told off to each, One man remaining at his post digging and loosening the earth ready for loading, whilst 3 men were engaged in working the wagon. On the return of the wagon the whole party dig, and aid in refilling it.- Filling a wagon by two men takes from 50 minutes to one hour, the earth being carried 30 feet on an average: Emptying takes from 10 to 15 Minutes These 10 or 15 minutes include all the time from the arrival of the first wagon at the spot where the earth is to be deposited to its leaving it again, by which time the last wagon of the train has also deposited its earth and commenced its return trip.—

In the 3rd Item where the wagon is propelled by Horses each wagon requires 2 Bilders for digging who remain at the excavations whilst the wagon is performing its trip and who refill it on its return. The Horses in this case being in charge of a Lads or groom specifically paid for the purpose A Horse travels at the rate of 2·85 miles per hour with a load, and 3·25 miles with an empty wagon.- 2 wagons are drawn by

One

One horse.-

Mr Parker in estimating the value of wagon labor with men and horses, has from a series of 5 months accounts in which are included the charges for excavating and carrying 1,317,000 cubic feet of earth, abstracted the following Tables, the first when the wagons were pulled by horses, the latter when they were pushed by men

Table 5.-

Average of Labor required for 1000 Cubic Feet of Digging, and carrying the Earth in Wagons drawn by Horses to a Mean distance of 9200 Feet, by Railway

Description	Average number	Remarks
Mates of Bildars	0·33	From this Table we find that 108 Cubic Feet is the days work of a digger, and 352 Cubic feet that of a horse
Diggers	9·23	
Horses Effective	2·82	
— Do — in Hospital	0·20	The diggers frame also to carry the earth in barrows, a mean distance of 40 feet in order to fill the wagons.
Do Non effective by Sundays Holidays Rain	0·70	
Men on Scaffolding and greasing wagons, Bildars	0·72	
Do Do Carpenters	0·08	

Table 6.-

Average of Labor required for 1000 Cubic feet of digging, and carrying the Earth in Wagons pushed by Men, to a Mean distance of 8700 Feet, by Tramway.-

Description of workmen	Average number	Remarks
Mates of Bildars	0·56	From this Table we find that 50 Cubic feet is the days work of a Man, digging and carrying.-
Diggers Barriers	19·70	
Men on Scaffolding and greasing Bildars	1·00	
— Do — Do — Carpenters	0·16	

The Cost of digging and carrying 1000 Cubic feet of earth as in the last Table, was Rs 3.13.0, which includes payment for Sundays, when no work is done - Had Sundays not been included, the cost to Government would have been Rs 3.3.0.-

In the same manner the cost of digging and carrying 1000 Cubic Feet earth as in Table 5 was Rs 3.12.0, detailed as follows, viz:-

Superintending	Rs 0.1.10
Digging	1.9.4
Carrying by Horses	1.10.2
Greasing and oiling wagons	0.2.2
Scaffolding	0.4.6
Total Cost Rupees	3.12.0

which includes payment for Sundays. Had Sundays not been included the cost would have been Rs 3.2.0.-

In

Alder

In the 1st Case it will be observed that the distance to which the earth was carried was 9200 feet on Railway; in the 2nd Case the distance was 8700 feet on a Tram-way, or on the flat bar rail before described. –

The above gives a fair return of the average on work done up to the end of April 1851. The following Tables represent the averages of the 2 following Years or up to the 30th April 1853, when the use of horses especially had become well matured, and at a time when a comparison between their value and that of Men as motive power could be better appreciated. The word comparison is perhaps not a fair one to use in this case, as the distances to which the Wagons have to travel is one of the chief elements in the rates, and these in the latter years have been much in excess to that on which the tables above given have been drawn up. The roads too have been much improved since the early days of progress, and experience and practice have rendered both Men and Horses more ready and expert in their respective duties

Average of Labor required for 1000 Cubic feet of digging and Carrying Earth in Wagons drawn by Horses to a Mean distance of 11300 feet. –

Description of Labor	average number
Mates	·62
Diggers	15·65
Men on greasing axles	1·20
Horses - Effective	3·95
do Non-Effective	·84
do Do in Hospital	1·16

64 Cubic feet = days work of a digger; and 253 Cubic feet = that of a Horse, excluding Sundays -

The cost of the work is as follows

Excavating = Rs 2·18 } per 1000 Cubic feet & or { Rs ·050 } per Ton
Carrying . . 1·43 } per 1000 Cubic feet & or { " ·032 } per mile *

Cost of Excavating is constant. that for Carrying varies with the distance - Hence it is 1·43 for 1 Mile, 2·86 for 2 Miles - and so on

These averages are obtained from the results of One years work - viz: from October 1832 to October 1833 - During this time 122 wagons were daily employed, and the total quantity of earth brought down from Makewan and deposited in the Aqueduct Channel, was 71,85,378 Cubic feet or 3,21000 Tons - Each working horse having by this time travelled a distance of 4278 Miles or 4 times the distance between Roorkee and Calcutta -

The lubricating Material for the axles was a Mixture in equal parts of Grease or tallow, and Mustard oil, and the quantity of this required for each Cart daily was 4 2/5 Chittacks

1 Cubic Foot of Earth weighs 100 lbs

* Weight of the Carts has not been considered

Average of Labor required for 1000 Cubic feet of digging and Carrying the Earth in wagons pushed by men to a mean distance of 2550 feet by Tramway -

Description of Workmen	Average Number	Remarks
Mates	·80	50·30 say 50 Cubic feet as the days work of a digger and Carrier
Diggers Hauliers	19·90	Average Cost =
Men on greasing axles	·61	3 Rupees for 1000 Cubfeet

These averages are obtained from the records of 1 Years work, leaving out the Months of December May, July & August when the Men were fined on account of little work -

During this time 19 wagons were daily employed and the total quantity of Earth carried by their means to the Rutmoo Embankments from Peeran Kulleeur was 16,52,644 Cubfeet or 73700 Tons - each Bildar having by this time walked a distance of 1190 Miles - a little further than from Roorkee to Calcutta -

When the Excavator does not carry the earth he has dug, it will be observed in the other table, that he does a daily task of 64 Cubic feet - This reduces itself - to 50 feet when he has also to carry the earth, as in this table: so that $\frac{50}{64}$ and $\frac{14}{64}$ will represent the labor done respectively to digging and carrying - In the present case where the two operations are combined Rs 2·34 and Rs ·66 will be what is due to each - The first always remaining constant, the latter varying with the distance, and increasing to 1·36 Rs when the distance becomes a Mile -

Hence 2·34 + 1·36 = 3·70 Rupees Cost for 1 Mile } per 1000 Cubfeet
2·34 + 2·72 = 5·06 " do · 2 Miles }

and so on —

On

On the 4th Item our ex=
=perience in rates of Earth as
obtained by the use of a Locomo=
=tive was too short to admit of
our arriving at any satisfactory
conclusions, an accident having
placed the Machine "hors du
"Combat" a few months after it
had been on the works. Lieut
Allen whose Establishment had
charge of the Locomotive attributes
no Blame to the Parties concerned,
the water had been drawn off,
and it was supposed that the
fire had been entirely extinguished;
a Storm with wind however, re
brought the fire and fuel which
were in the furnace into action,
destroyed the casing and a num.
=ber of the tubes, and placed the
Locomotive completely out of
use. This misfortune although
it put a stop to the use of a
power which I had anticipated
as one that would be of great
service to us, and in some de=
=gree make us independent of
Pikemen or diggers; may not be
considered altogether as the cause
of the Locomotive having been
discontinued. Valuable as it was
as an adjunct to the Motive
power which we already possessed,
it had the inconvenience of oc=
=cupying an entire line of
railways, to the prevention of its
use by the numberless Waggons
that were required not only for
Earthwork but for the Carriage
of Materials. We had not a
Sufficiency of rail to provide
separate accommodation for it,
nor had we leisure (as time was
a great object) to make Sacrifices
for

for the purpose of keeping the Engine at work. Laborers appeared to be in sufficient & abundance, and the Horses which at this period were very generally employed, gave steady occupation to the Wagons, which the constant interruption arising from repair to the Locomotive prevented in a very serious degree. This evil might perhaps, have been remedied had we, instead of having only one, had 3 or 4 Locomotives by which a perfect might have been substituted for an imperfect machine, but there can be no doubt that although the Locomotive that we had was placed in the hands of a practical & Engineer, Mr Murdoch, who (although he had never been actually employed as a driver or stoker on railroads) had all his life been connected with & steam Machinery, the Engine was in some way or other imperfect in the adjustment of its ~~Parts~~ parts, it was continually getting out of order, and appeared to be another specimen of "Machinery ~~for~~ exportation ~~to~~ "the Colonies". -

The Engine that we received at Roorkee was made by Fawcett & Co, it is small and compact; Engine and Tender in one frame; adapted from its water and fuel arrangements to moderate distances only and applicable to draw on a level line of Rail a train of Ballast wagons of an aggregate weight of 180 to 200 Tons at a speed of 4 Miles an hour. Of the parts most liable to fracture

we

we have duplicates, as well as of the wheels both driving, tail and leading. Its name is the "Thomason." The Executive Engineer in charge of the Northern Division of the works in writing to me on the subject of its applicability for the particular duties which the Aqueduct works required from it, remarked "The Locomotive started first on the 22nd December 1851, at the Roorkee end of the Railway, my intention being to teach natives to drive at that end, as being more convenient to Mr Murdoch, whose other duties required his presence in the workshops. Moreover, the employment of the Locomotive on the Mukewa Channel line would have thrown a large number of horses out of work, and would also have seriously interfered with the general usefulness of that line in respect of carriage of materials. It soon became necessary, however to repair the light Roorkee line which is laid with flat iron, and what with these repairs constantly repeated, and what with interruptions of other sorts, Mr Murdoch's attention being much required on the condensing Engine and workshop Machinery, at first the driving did not progress very fast. After repeated repair it became evident that the Roorkee line could never be made available for the Locomotive, owing to its weakness, and but for the necessity of teaching native drivers whilst

the

the weather was cool, I should have preferred shelving the Locomotive for the time being - As it was, di-=rectly I was satisfied of the im-=practicability of working the Locomotive on the Roorkee Line, the new Muhewar Embankment line was pushed on as rapidly as possible, and on the 15th of March last having a portion of the latter line on which + horses could work, although Still under some disadvantage, the Locomotive was removed over to the other side of the River, and the subjoined table will Shew its performances during the remainder of that month

Date		Number of Loads	Quantity of Earth carried	Distance
1852 March	22	30	Cubic feet	Running feet
	23	23		
	24			
	25	20		
	26			
	27		18057	15000
	28			
	29	75		
	30	89		
	31	90		

Captain Goodwyn continues "That nothing but the necessity of + teaching natives to drive during the cold season, and shame at seeing the Locomotive standing idle, has induced me to allow it a place on the Muhewar Channel line - I have done it in Spite of my better judg-=ment, and now the running of the Engine is getting into order, I do not like to break up the arrangements, although until the Muhewar Embank-=ment

=ment railway is run out much
further; we are, I consider, using
the Locomotive at an extrava
=gant loss".-

"The want of progress of
the Muhewan Embankment
railway has been caused in=
=directly by the sickness of the
officer in charge, I have done
my utmost to push it forward
since the middle of February
During the month of April the
work of the Locomotive has
shewn a considerable improve.
=ment, and once the Engine
has brought 114 loads during
a day - Advantage was taken
of the presence of the only well
trained driver being required
at the Roorkee workshops to
attend the condensing Engine
for a few days, to take up the
only portion of the line traversed
by the Locomotive laid with
flat iron, substituting in its
place English rails - During
this operation the working of
the Locomotive was stopped
and hence its progress report for
April will shew rather poorly"

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Date	Number of Days working	Number of Loads drawn	Quantity of Earth Carried	Distance
			Cubic Feet	Running feet
April 1852	10	687	34,350	14,000

During the 10 days included in the above
Table 16½ Trips were made by the
Locomotive; giving an average of 41½
Loads per Trip. or 68·7 Loads per diem -

Hall

At a rate of about 10 Miles an hour, the Engine with an accommodation carriage and string of 10 loaded wagons passed over the rails very easily and quietly; the difference between the motion when passing over the English rail and the Iron bar, being as I before remarked very remark=able, the former being as superior to the latter, as a Kilmarnock Metalled road is to a common District one. Mr Murdoch on this occasion as he had on former ones, adverted to the absence of Coke, and the use of Wood and Charcoal as a great loss to our Steam Furnaces; he informed me that even in the short distance upon which the Locomotive run which at that time did not exceed 2½ Miles, he was forced to carry an extra 4 wagon for tender purposes.

As an aid to our operations in constructing the Aqueduct, the Locomotive has been a failure, not from its want of value as a motive power, but from its inapplicability to the local circumstances under which the work was carried on; the extract above given from the Executive Engineer's report shews very clear=ly the difficulties under which he labored.

The Engine attached to the Locomotive was in its original design so contrived as to be adapted to use as a fixed one in the workshops. In so far

therefore

Therefore, our want of Success on the Road has been met by the introduction of by no means an useless addition to our workshops steam power, whilst at the same time the Engine is available for its purposes as a Locomotive at any future time when it may be wanted. I fully anticipate that such will be the case on the Railroads that will ultimate=ly be Established on each of the Aqueduct Embankments, extending from Roorkee to the Rutmod; here the immediate dispatch of Stores & Materials, or in the case of Earthwork re=pairs, the rapid collection of Material for the purpose, will be very satisfactorily met by the presence of a Machine of this description.

From the above it will be seen that to Men and Horses we have been indebted entirely for the progress made in the execution of the Earthen Aqueduct. this progress has been from early in 1848, upto the 8th April 1837, in a State of steady advancement, and both our Men and our Material are in a high state of Efficiency

The two following Tables will give an idea of the rates of Earthwork as executed, they are those charged by the Executive Engineer in his Quarterly Bills and include all Contingent Expenses dependant on the re=pairs and Maintenance of the

the plant. The first shews the cost where men are used as propellers to the wagons, the latter where horses pull them.

Rates of Earthwork as Executed on the Solani Earthen Aqueduct in Ballast waggons propelled by Men

Distance Runs Feet	Rate per 1000 Cubic Feet Including Spreading			not Spread			Remarks
	R.	a.	p.				
447	4	7	9	"	"	"	Rammed
1500	4	9	10	"	"	"	
1500	4	15	4	"	"	"	
2000	5	2	4	"	"	"	Rammed and watered
2000	3	2	3	"	"	"	
2200	5	3	8	"	"	"	Carried to vaults & Puddled
2760	3	9	6	"	"	"	
3070	3	12	2	"	"	"	
3240	2	15	5	"	"	"	
3350	"	"	"	2	8	4	
3387	3	10	2	"	"	"	
3483	3	4	10	"	"	"	
3918	6	6	11	"	"	"	Carried to vaults & rammed and watered
4000	2	4	9	"	"	"	
"	3	2	8	"	"	"	
"	3	3	8	"	"	"	
"	3	4	1	"	"	"	
"	3	4	9	"	"	"	
"	3	8	8	"	"	"	
"	3	9	10	"	"	"	
4029	3	13	8	"	"	"	
4030	3	15	2	"	"	"	
4125	3	14	4	"	"	"	
4150	3	6	8	"	"	"	
4200	4	1	6	"	"	"	
"	4	2	4	"	"	"	
"	"	"	"	2	12	5	
"	"	"	"	2	13	4	
4433	3	7	4	"	"	"	
4440	3	14	2	"	"	"	
4720	"	"	"	2	14	7	
4766	3	11	8	"	"	"	
4947	3	14	2	"	"	"	
5000	"	"	"	2	13	10	
5200	"	"	"	3	14	1	
"	"	"	"	3	15	7	
5350	"	"	"	3	7	1	
5366	4	2	5	"	"	"	
5400	3	8	9	"	"	"	
5407	"	"	"	3	14	1	
6594	4	3	11	"	"	"	
6800	4	1	8	"	"	"	
7000	3	11	10	"	"	"	
7215	"	"	"	3	11	3	
7672	"	"	"	3	5	"	
7702	"	"	"	3	5	2	
7783	4	7	6	"	"	"	
8000	"	"	"	3	2	6	
"	"	"	"	3	13	10	
"	"	"	"	3	14	8	
"	"	"	"	4	4	1	
8180	"	"	"	3	11	3	
8230	"	"	"	3	8	2	
8446	"	"	"	3	8	2	
8456	3	4	10	"	"	"	
8500	"	"	"	4	4	4	
8843	4	10	7	"	"	"	
9000	"	"	"	7	9	"	
9030	6	4	1	"	"	"	
9186	5	13	1	"	"	"	
9365	5	3	11	"	"	"	
11200	"	"	"	4	0	5	

Rates of Earthwork as executed on the Solani Earthen Aqueduct in Ballast wagons drawn by Horses.—

Distance Rung Feet	Rate per 1000 Cubic feet exclusive of Spreading Rs	as	p	Remarks
7000	3	4	6	
7500	3	4	10	
8673	3	8	10	
8540	3	13	2	
8840	4	15	8	
8960	5	7	10	
9400	5	9	10	
9650	5	4	9	
10175	4	12	2	
10760	5	0	8	
10763	3	9	1	
11200	5	..	5	
"	5	15	5	
11520	5	2	..	
11556	5	3	2	
12000	5	12	9	
12205	5	4	3	
12400	5	2	..	
14430	3	13	4	It is remarked of these rates that they were too good to last.
15000	4	3	2	

XI The Sectional form of that portion of the Aqueduct which we are now describing is shewn in Diag: CXLI, ~~which~~ represents the work as it will be on the completion of the boulder bed, ~~which it is proposed~~ to be extended over the whole of the Earthen Channel, as a protection against the wear and tear of the current. The depth of this layer of boulders (or round stones from the Ganges River and its neighboring branches) will be two feet, the Stone ought to be of the largest description procurable, as its value for the purpose intended will depend in a great measure on its consistency. To relieve the works from such a heavy cost, as the transport of so much material by land carriage would entail upon the Estimates, this portion of the undertaking has been reserved

until

until after the admission of water into the Canal, when the facilities offered by water carriage will render this part of our operations comparatively simple. For this purpose a number of Iron boats have been built ready to put on service immediately the time for floating them arrives, these with the boats which have been used for a considerable period on the Navigable Canal for the same purpose in bringing stones from the Ganges to the Ranipoor works will give a very good fleet to begin with - I would recommend however, that the manufacture of either the same class of boat now used, or of a better sort if such is thought necessary, should be continued, until there is a sufficient number to provide Bridges at the different navigable heads, as well as for the transport of Stone; for these purposes at least 200 boats might be completed with very great advantage. At the present stage of the Earthen Aqueduct, the Canal bed is raised ~~on an average 12 Inches~~ above the true level, so as to admit of Settlement and consolidation, the delay in depositing the Stratum of Stone will be so far advantageous that it will give time for this consolidation. Taking a practical view of the method to be adopted in the immediate vicinity

* In laying down the Stone, I would recommend that it should first of all be completed -

vicinity of the Aqueduct proper,
or in those regions where the bed
is the most Elevated, and where
the side Revetments are necessarily
the least protected. After this was
finished, a width of 40 feet or there
-abouts, laid in on the sides of the
Channel nearest to the Revetment
walls on the whole length of the
Earthen Aqueduct would be the
most desirable position for the
stone. The Centrical part of the
Channel would be the last in
sequence of this most necessary
part of the Operations. A good
deal of Settlement, and probably
of an irregular nature may be
anticipated on such a long line
of artificially raised earth; a
careful watching of progress in
this point will naturally be the
earliest consideration, and it is
my opinion that many years
will elapse before we can hope
for the Establishment of a bed
sufficiently permanent to admit
of the full supply, nor can this
permanent bed be hoped for,
until the Stratum of Stone has
been laid over the whole of the
Surface. It is in vain to expect
immediate results in the early
deliveries of large masses of water
upon the high land of the
Doab at Roorkee, until the
works in the Khadir, especially
those appertaining to the Solani
Valley, are fairly Established.
The delay that I anticipate
is from the bed of the Earthen
Aqueduct

Aqueduct merely; the effects upon this part of the work will be the measure by which we can regulate the admission of supp-=ply; the constant necessity for laying this work dry, and the importance of doing so for the purpose of watching the ac-=tion of the Current are matters upon which its ultimate se-=curity, and in fact its early efficiency as a permanent line for the carriage of a body of water depends. - No feelings of disappointment, nor of desire for rapidly gaining results, ought to militate against the views which I have here recorded. - The works are of a nature unknown in any of the Canals yet constructed in these Provinces, and I believe that the difficulties which we have had to contend with, + with the impracticability of dis-=posing of the Torrents excepting by maintaining them on their natural courses, will be hereafter (even when Canals are taken from all the great Rivers that debouche from the Himalaya as they now are, a remarkable feature of the Ganges Canal works. - At any rate the pe-=culiar nature of these works demands peculiar treatment and it can only be by slow and deliberate management that they can be expected to answer the purpose for which they were designed. -

Cash = It remains now for me to

to say a few words, in closing this Section, on the Masonry Works which are attached to the Earthen portion of the Solani Aqueduct. I have described their design and would for further explanation on this point refer to Plate XXVII of the Atlas where drawings are given in detail. The terminating bastions or the Circular Masses of Masonry which come in contact with the Canal Channel on its approach to and departure from the Aqueduct owe their decorative character to the figures of Lions on the Pedestals, to the talent and Architectural Skill of Lieute George Price, of the 1st Bengal Fusiliers, the Assistant Engineer under whom the Aqueduct proper was constructed. The Figures although neither of Bronze nor Stone, but of plain Brickwork, have the merit of being made from the material on which our resources have depended. In this respect they are in my view of the case more satisfactory than had they been of a higher order of art, imported from Europe: they are specimens of the work of our own Engineers, and as such are alone deserving of credit. The Masonry of which they are built, both as regards brick, lime and workmanship, ~~is~~ of a very superior description, they are stuccoed, and as I have before remarked

they

they are well elevated on their
Pedestals, and look outwards
from the Aqueduct.

The Bridges are as I have
before noted, on the design~~ation~~ des-
-cribed as Class No 1 in the Chapt-
-ter on Bridges, they are plain
with the Cutwaters Surmounted
by Niched Pilasters; the water
way consists of 3 bays with
Elliptical arches of 55 feet Span
each; for a distance of 350 feet
on their up and down Stream
faces, or on that portion of the
Revetted Aqueduct which is
described on Ogee Curves, the
Steps or Ghats are cut off from
the Towing Path which passes
round on a ramp made es-
-pecially for its convenience,
and are designed for the accom
-modation of bathers, who can
here perform their ablutions with
-out interference from passers by
The line of Ogee on each flank
is in fact a "Cul de Sac" ter-
-minating on the face of the
bridge, near which are steps
for the convenience of passage
between the high and low levels

The Cattle Ghats which
lie between the Lions and the
Ogee Curves of approach to the
Bridge, are works which will
be duly appreciated by the
Village Community in the
accommodation that they offer
to their Cattle; in addition to
this at low water they might
offer convenient points for the
loading or unloading of
rafts for which the inclined

planes

planes upon which they are built are well adapted. I have before observed that the line of communication along the berm is maintained across these Cattle Ghats by arches which render the whole an unbroken and continued line

The Revetments were laid in to a depth of 12 Inches below the natural Surface of the valley, they were either filled with earth consecutively with the progress of building, or the earth was thrown in afterwards, upon this earth which acted as centres, the arches were con=structed, so that the whole mass is formed of well consoli=dated earth, protected on the sides of the Channel by Masonry.

It was a question, whether to leave the Revetments hollow or to fill it with earth; the reasons which decided me on the latter course were, 1st, that taking the proportions of Fig II Diagram CLXII it appeared to me doubtful whether the walls were sufficient for sta=bility without the interior sup=port of earth, especially when the height of the Revetments was at its maximum, in this doubt I took into con=sideration the possibility, if not certainty, of the interior being filled with water as well as the chances of the action of the current laying the Channel front bare to a considerable depth. The mere hollow V

hollow shell offered by the Revet=
=ment figured above appeared to
me to be an insufficient protection
to the Embankments, and with other
evils, to give facilities for leakage.
On the other hand, well rammed
clay in the interior would add
to the water tightness of the Chan=
=nel in its elevated position above
the valley; the construction of the
Arches and building in general
would be greatly simplified by
the interior being filled with
earth, and the only objection that
existed, as far as I could gather
was from the effect that absorp=
=tion of moisture by the Earth
or clay might have upon the
enclosing walls. The advantage
in favor of solid over hollow
Revetments appeared to me to
be sufficient, to prevent the ob=
=jection above specified from
influencing me in the selection.
The value of these Revetments
depends so much upon the
efficient maintenance of the
Canal bed, that in giving all
our attention to protecting the
latter, and in strengthening
it by all the means in our
power, we in fact do the same
service to the Revetments

I have before remarked
that with the exception of Kun=
=kar and vitrified brick which
comparatively speaking have
been very sparingly used, the
whole of the Revetment and Terminal
works are built with brick
masonry, with a Lime Cement
mixed in the following propor=
=tions

=tions

1 part of Stone Lime
1 — do — Sookee
1 — do — Sand

The brick has been denominated 2nd Class from the circumstance of the best having been selected for the Aqueduct proper, for the bridge Arches, and for other por=tions of the work where the hard=est material was required: although bearing the name of 2nd Class, and not so well burnt as the other, it is not to be un=derstood that the brick was of a bad quality; the material was sound, and well burned, and would have been received as such on any large board of works - These bricks in fact were very much better than those used for building purposes in England, and as far as I observed, equal to any that I saw on the Con=tinent of Europe.-

The whole of the outer surface has been Stuccoed with a Cement of the following pro=portions.-

1st Coat { 1½ parts of Stone Lime
1 — do — of Sookee -

2nd Coat { 2 parts of Stone Lime
1 — do — of Sookee

I have in Plate XXVII Atlas, Print No 14 given representa=tions of the Kilkenny and vitrified brick building as executed; the former when not laid in blocks was used as beton inclosed in brick work strengthened by brick bond: the latter is in horizontal courses, alternating with Brickwork the alternating lines being bounded

A

bounded by brickwork introduced vertically at fixed distances.—

The above gives as full a detail as appears to be necessary on the Earthen Aqueduct line, the great extent to which it is carried rendering it the largest as well as the most important part of the Ganges Canal works — We now, therefore proceed to describe the Aqueduct proper, or that portion of the works over the Solani River which comes in immediate contact with the Torrent for the passage of which provision has been made below the levels of the Canal bed.—

Section II. Masonry Aqueduct connected with the Solani Torrent.—

On my return from England early in 1848, I found that the block sinking of the foundations had been commenced, that the whole of the blocks of Six piers on the right or Roorkee side had been completely sunk, and that others were in progress. Referring to Plate XXVII of the Atlas, at the period that I allude to, the state of this portion of the work was as follows:—

Completely Sunk	Nos	40. 41. 42. 43. 44. 45. 46. 47. 55 56. 57. 58. 59. 60. 61. 62. 71. 72 73. 74. 75. 76. 77. 78. 135. 136. 137 138. 139. 140. 141. 142. 151. 152. 153. 154. 155. 156. 157. 158. 167. 168. 169 170. 171. 172. 173. 174
In progress of Sinking	Nos	102. 103. 104. 105. 106. 107. 108. 109 110. 119. 120. 121. 122. 123. 124. 125 126.

some subordinate earthwork in the way of Coffer dams for the protection of the above abutment, and a cut made on the left of the river, to facilitate the passage of the Streams on the down Stream side of the works, and which existed on my arrival under the name of "Strachey's Cut," had also been done.- The state of the works on my return was that of full progress in block sinking.-

Certain alterations had been made in the arrangement of the blocks, of the abutments and wings.- Lines of blocks had been recommended by Major Baker in substitution for the sheet piling which was proposed for the front and rear aprons; and the Cutwaters which had in my design of 1845 been proposed as mere appendages to the floorings and apron, were recommended to be founded on blocks sunk to an equal depth with the rest of the Foundations The alterations made to the abutment blocks depended on an increase to the thickness of the Abutments themselves, which from 15 feet were extended to 21 feet; the blocks of the wings had been altered I believe for the sake of economy, the Evenly sized blocks which were originally designed, having given place to an outer line of large, and an inner line of blocks of a smaller size.- The substitution of blocks for piling at the head

and

and tail of the Aprons, and ~~of~~ giving ~~to~~ massive foundations to the Cutwaters, were to reduce as far as was possible the effects of percolation and removal of the subsoil from the floorings as well as to give to the floor=ings and to the protective ar=rangments in their front and rear, greater strength and sta=bility than piling offered.— The whole of these alterations were carried out as far as they could be.—

Alter

The Superstructure of the aqueduct is unaltered in its general character from that which was originally designed; additions have been made in connection with the canal bed both on its up and downstream ends, and in detail of construc=tion, slight deviations (all of which will be described in their proper places) have been made adapted to particular circum=stances.—

In Elevation the design architecturally speaking is the same as it was originally planned in my report of 1839/40. The wings have been altered to broken rusticated basements, supporting pedestals; and the Pilasters over the Cut waters have been pierced by Circular holes which are intend=ed for the ventilation of the Spandrils; these with a form of Cutwater somewhat modified from

from the early drawings are the only deviations from the design as first contemplated.

The work will be understood by reference to Plate XXVII of the Atlas, and to the series of plans which shew the works on the Solani valley. In viewing it from the valley, it consists of 15 Arches of 50 feet Span each; the line of Arches being terminated by rusticated Wings, each of which support Pedestals, on which are Lions similar to those placed on the Terminal works, although of larger proportions. These Lions face inwards, looking towards the Solani River; and guarding the Portal by which the Torrent passes through the works. ~~They in fact hold the position of the Sphinxes at the Egyptian Temples; the stream of the Solani passing between the guardian Lions in its way to the all absorbing gulph of the Ganges, as that of the population of Egypt may be supposed to have done in its progress through the avenue of Sphinxes towards the huge Propylæa which terminated the approaches to the Altars of Isis.~~

They are in truth arranged as were the Sphynxes in the Egyptian Temples: and as in those old days the stream of Nile worshippers passed on between these guardians to the vast Propylæa which terminated the approach to the Altars of Isis, so the Solani now passes between the Sacred stream of the Ganges between guardians equally appropriate & similarly placed

The foundations of this building will be first considered. I have before described the nature of the Torrent, the sandy character of its bed, its saturation with Springs; and that although during floods it is the bearer of an enormous quantity of water, at

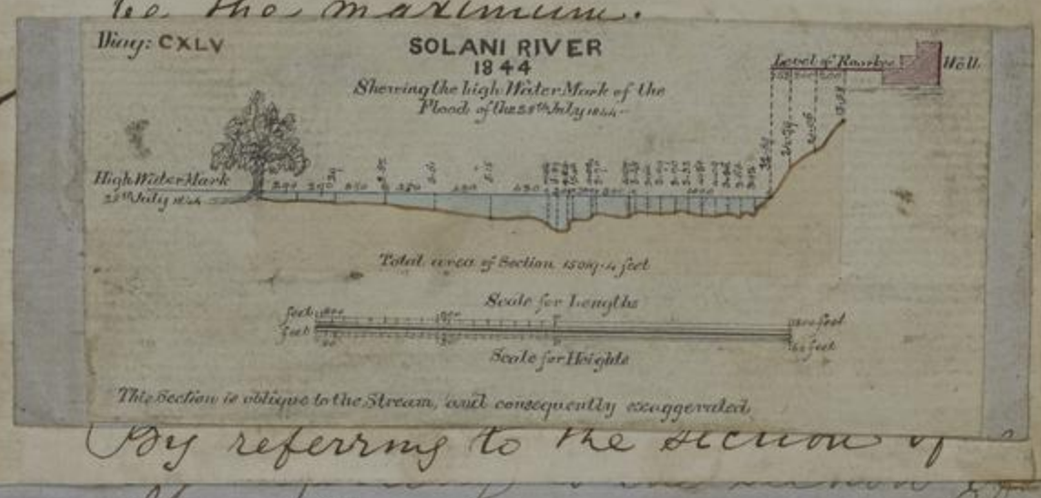
at other periods its stream is quite insignificant, varying from 5 to 20 Cubic feet pr Second, whilst in extreme droughts, a superficial run of water ceases altogether. As the dimensions of the Foundations are depend-ant on the Amount of water way of the Superstructure, the circumstances by which this was determined may be best explained before I commence upon the details of construction. The original design for the water way of this River which accom-panied my Estimates of 1840, gave 9 bays or openings of 56 feet each, or an Escape in the aggregate equal to 504 feet; this was founded on calculations of floods observed by the natives, verified in some degree by existing marks of High water. The results were derived from observations hastily taken during the course of a Survey which with its field work, plans, Estimates and report were all concluded within the Space of five Months. Further observations, however, appeared to sustain the correctness of these calculations, but in 1845 a flood which occurred during the residence of Capt^n Turnbull of the Engineers at Roorkee, al-though it did not exceed the capabilities of my Aqueduct, led to Speculations as to the propriety or otherwise of extending the

the dimensions of a work, upon
the Stability of which the Canal
depended. In submitting my
report (with Estimates) of 1845,
therefore, I went into some detail
on this matter, and as the remarks
that were then made will be
interesting ~~as~~ as shewing the grad-
-ual progress by which the
Aqueduct reached its present
dimensions, I shall here state
the views which I then held,
premising that up to the floods
of 1844. I had determined on
so far modifying the former
design as to give a clear water
-way of 500 feet broken into 10
Spans of 50 feet each, with a
reduction of dimensions to the
Piers, so as to render the ~~obstruction~~
as small as possible - "In the
above Estimates I remarked (re-
-ferring to those of 500 feet waterway)
"for the passage of the Solani
valley, I have with reference to the
probable height of the most ex-
-treme floods, projected works
which from the calculated
discharge and area of the
flood water of the Solani River
appeared to me to be amply
sufficient; there were no indi-
-cations of floods having reached
to a higher level than that shewn
in the Sections above given, and
the cultivated state of the tract
of low land lying between
Bajoohera and Roorkee did
not tend to the most remote
inference that floods ever occurred

of

of such a magnitude as to lead to their entire inundation.

The following Section is that of a flood which occurred on the 28th July 1844, the extreme height exceeded by 3 feet that which had been supposed to be the maximum.



By referring to the Section of the valley between Bajoohera and Roorkee, it will be observed that the inundation arising from this flood, extends across the whole surface, its duration at the extreme height did not continue beyond an hour or two in the middle of the day, but at 7 P.M. it was running at a height equal to the highest flood of 1843. I had in my report of 1840 adverted to the circumstance of the country lying at the foot of the Sewaliks being occasionally visited by floods of extraordinary magnitude, and that in projecting the water way of the Solani Aqueduct, the passage of unusual floods had been provided for. This which was written in 1840, was justified by an experience of 12 years passed in contending with 3 of the mountain torrents connected with the Sewaliks, 2 of which were first rate. In the

of
the capriciousness of these Tor-
^rents I had not been an in-
=attentive observer - The pe-
=riodical occurrence of remark
=able floods, confined apparent=
=ly to the watershed of the
Jumna ~~was exhibited in the~~
rains of 1842. The fall of rain
which led to the floods of that
year, appeared to be confined
entirely to the Sewalik Hills
and to the ~~forests~~ lying at their
base: the Mountain streams
and Rivers connected with them
and with the Jumna Drainage
~~basin~~, were charged with a
supply of water not known
before for many years. The
Canal works suffered
derably. The Bridges on
gh road between Saharunpoor
the Ghurmooktesur Ghat
of which had remained
unrepaired since their con-
=struction 20 years before) in
crossing the Dumola, Hindun,
west Kalli Nuddi and other
streams tributary to them were
also sufferers in a greater or less
degree; Yet during this excessive
flood which affected the country
even at the head of the East
Kalli Nuddi, the Solani River
did not rise above the extreme
high water mark noted in the
Sections that accompanied my
plans of 1840 - The remarkable
fact is that although the
drainage that supplies the
Solani is perfectly distinct
from that which feeds the Rivers
above

above alluded to, the waterheads of each are in contact, and it was natural to infer that the heavy rains that led to the floods of the Dumna slope, were common to the line of Hills and Forests extending over the heads of the Solani. Local falls of rain however, are by no means of unusual occurrence in these regions, they in fact become one of the many difficulties with which we have to contend in our de=vices for regulating supply, and frequently lead to catas=trophes at one point of the works, when at others no rain has fallen at all.. During the floods of 1852 to which I have above alluded, as causing such destruction to the bridges con=nected with the rivers under their influence the high water on the Ghazioodeenuggur Bridge (a work built over the Hindun not far from its confluence with the Dumna although a long way below the junction of the Dumola, west Kalli Nudi, and other tribu=taries to which it owes its supply) was very much in excess to that of 1841.- Here, again, local circumstances affected the magnitude of the floods. In 1852, The bunds which are connected with the Eastern Dumna Canal works, and which are raised to prevent the water of the Muskurra from reaching the

the works, by throwing its supply into Cuts connected with the Rindum, remained uninjured during the rainy season, whereby the whole of the drainage from the Sunsurra and Kalowala passes flowed down the Rindum - In 1845 on the contrary, the bunds in question broke, and the Rindum was thereby relieved of so much flood water.-

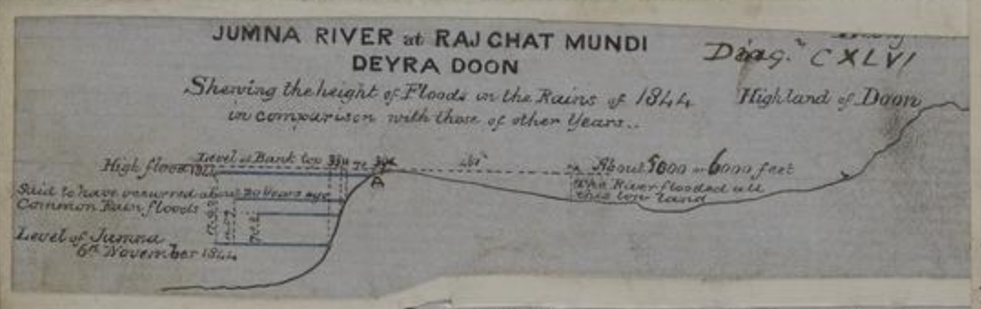
I am prepared for the remark that with such an extended section as that shewn in Diag: CXLV, a portion of the water would be still or merely inundation; it is difficult to say to what extent this might exist, and the impracticability of measuring the superficial velocity on different portions of the width of a river of this description so as to obtain an approximation to the mean of the whole section, leaves us entirely dependant on calculations based on the observed slope of the bed of the River; which although they may be considered accurate when the stream in the Channel of a Canal or River is compact and of one depth of section, are not to be depended upon in floods rising above the banks, and inundating the neighboring country - As an exemplification of this we may refer to Diag: CXLV which

(465, 2 H, vol 2, p. 3, C IX. Wiltshire)

which merely exhibits the section immediately in the region of the bed of the Torrent; now, calculating this with reference to mean Velocity deduced from the slope of the River, we have a discharge pr. Second equal to 84108. Cb. Cubic feet, a volume of water which is ten times as much as that which flows in the Ganges during the dry months of the year, and half as much as that of the Rhine on the French frontier which is said to be equal to 163253 Cubic feet pr. Second. It is impossible to consider (when estimating the Surface of the Country & bounded by the waterheads of the Solani above the Aqueduct, or in other words the Catchment basin which throws its water upon the point where the above section was taken) that so much rain could have fallen and the inference necessarily is that the mean velocity of the water running on the above Section could not have corresponded with the slope of the bed of the Torrent.. I may observe that the section to which I am referring was by some mistake or other & taken obliquely to the course of the River a circumstance which "per se" affects its value. The results of this observation were no doubt of great importance, the floods of 1841 were of extraordinary amount on the

Summa

Jumna as well as on the Ganges
water shed, Villages built on ground
usually out of the reach of high
water mark were swamped and
Cattle drowned. Old branches of
the Jumna which for years had
been dry, and which previously
to the floods of 1841, were covered
with Forest and gigantic Bur
and Simmul trees, shewing how
long they had remained free from
the effects of flood or running
water, were during this year
swept out, and restored to their
former state of River beds; from
this era in fact we date very ex-
=traordinary changes to the amount
of water thrown down the Boodhee
Jumna during the rainy season,
and an increase of volume which
in preceding years had been com-
=paratively unknown. In
concluding the subject of the
floods of 1841 and 1844, and
in further exemplification of
their height in the latter year,
I append a series of observations
taken by me in the cold weather
of 1844/45 on the main Jumna
at Rajghat in the Deyra Doon.
The Site where the section em-
=bracing this series was taken
was at the Ferry immediately
before the River enters the Sewalik



Diag.^m CXLVI

NB. The Floods of 1844 stood over the floor of the huts at A; the Old encamping ground near them, was swept away, with Timber of all sorts which had been collected and placed on ground considered to be perfectly safe and out of the reach of Floods.

P. CXLII

Note for the printer

B. Level of bank top
C. High flood - 1844.
D. Said to have occurred about 20 years ago -
E. Common Rain floods
F. Level of Jumna 6th Nov.r 1844
G The river flooded all this low land

Examinations

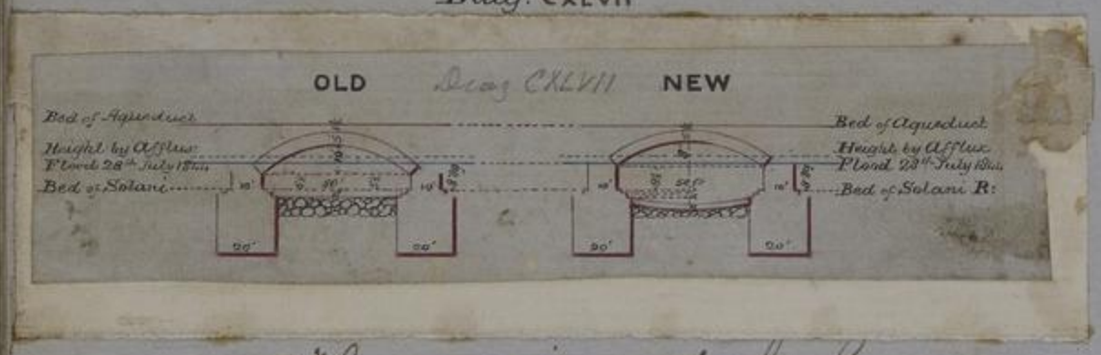
it lies between the junction of the Girree and Asun rivers with the Yumna, a point that I was well acquainted with, from having annually, for many years, fished in its neighborhood: my surprize in observing the effects of the floods at this point was very great, large tracts of elevated table land on the edge of the River which had been always in my recollection used as stacking places for Timber, were washed away; the shape of the River was changed, and the Gurree which in former years entered the Yumna at a point on the right immediately above the site where the Section was taken, had taken up another position entirely.—

In considering the floods both of 1812 and 1814, it became evidently necessary to anticipate the recurrence of similar or even larger ones, and with this view, I increased the waterway from 10 to 15 bays of 50 feet each, giving a total width of 750 feet; by adding counterarches and otherwise strengthening the floorings, and by remodelling the transverse section of the superstructure to meet the increased head water, the capacities of opening for the Torrent were sufficient for floods of even a greater magnitude than those of 1814.—

The improved Section at this

this Period will be understood by reference to the following diagram, shewing the waterways formerly proposed, and those determined on in 1815. It is interesting to place these Sections upon record, that we may compare them with that which was ultimately built

Diag: CXLVII



The design of the foundations was adapted to a waterway of 15 Leaves of 50 feet each, with Piers of 10 and abutments of 21 feet in width the latter being flanked by the wing buildings which were connected to and continuous with the Revetments and Embankments of the Earthen Aqueduct. The extreme width of the Channels for carrying the Canal water over the Solani, including their walls or Revetments, was 192 feet. The total Superficial area that the body of the Aqueduct covers was 178,944 Sq: feet or 932 feet in length and in breadth 192 feet: detached from this Series of foundations which were distinctly for the support of the Superstructure there were advanced lines of blocks in substitution of the Sheet piling which had been originally proposed, as well as blocks at the terminal points of the piers for the

the support of the Cutwaters. These, with the blocks for the support of the wings and lines of Revetment forming the flank approaches to the Masonry from the Earthen Aqueduct, constituted the work to be done in block sinking.—

The total number of blocks which are included in the different parts of the work above referred to, amounted to 338 which for the convenience of reference and account, were numbered, and were divided into 4 classes depending on the horizontal measurement. These classes were as follows:—

	L	B	NUMBER	Total Number
1st Class	26	22	16	20
D.	25	20	4	
2nd Class	22	20	112	120
D.	20	18	8	
3rd Class	21	16	12	72
D.	16½	12½	60	
4th Class	20	8	28	126
	22½	6	8	
	20	10	2	
	19	10	6	
	17	10	4	
	20	6	52	
	15½	6	26	
			Total	338

In addition to the above the flights of steps, built in the form of ~~II~~ Quadrants which terminated the Aqueduct wings, and acted as curves to the Embankment Slopes on their reaching the Aqueduct proper, were built upon circular wells, of which there were 4 to each Quadrant, or to each flank of the main building.- The total number of these wells was 16.-

The plan of the foundations in all its detail is shewn in Plate XXVII of the Atlas; this plan exhibits the precise position of

of each block when first built, and as laid in the true alignment of the work, it also shews the state in which the different blocks existed, after their undersinking had been completed, and after the blocks themselves had passed through the ordeal of the downward movement which necessarily more or less affects their position. A careful observation of this plan is interesting as explanatory of the very small change that has taken place in sinking large masses of masonry to a depth of 20 feet, whilst in the smaller masses, especially in those where there is an aberration to any extent from the perfect Square, the movement is more considerable

The Method of undersinking is practised by the Natives of India (in the North West Provinces especially) to a great extent, it is universally adopted in wells for drinking purposes, and is largely used by their Engineers in obtaining supports for their masonry works, when the soil is either sand, or of a treacherous nature; in such cases, Cylinders of masonry are sunk either at distances apart or close together, and upon their tops which are arched over and connected by masonry or other bonds, they raise their superstructure In all the works which I had built on the Eastern Jumna Canal, this species of foundation had

had been used with great suc
=cess, and on the Western Jumna
Canal, Colonel Colvin who laid
the foundations of the Dadoopoor
Dam had extended the principle
by undersinking rectangular
masses of the following dimen=
=sions L 15 × B 4 × D 10 a good deal
of the undersinking being carried
through small shingle. Colonel
Colvin had with greater or less
success also, sunk the piers and
abutments of small bridges,
which required deep foundations,
the whole pier or abutment being
undersunk in one mass. The
success with which this had been
executed, shewed that the principle
of undersinking might be ex=
=tended to very large masses of
masonry, and in planning the
Solani Aqueduct, I extended it
to Cubes of 20 feet, this dimension
it will be observed has been in=
=creased at the Dhunowri works
where the maximum horizontal
dimension of the blocks is equal
to L 30' × B 30' the depth to which
they were sunk being 20 feet.
In detailing the progress of the
block sinking I shall draw at=
=tention to certain laws which
appear to guide the proportions
of these masses of masonry, but
in a general way the difficulties
of sinking at all, and the danger
of the blocks going down un=
=evenly, increase as the form
wanders from that of the square
or the Circle.

From the nature of the River

River with which we had to deal, the character of its bed and slopes, and the existence of springs on the surface, it was clear that there was no method of laying the foundations in the usual way by excavation; the alternatives lay between the European system of piles, and that adopted by the natives of masonry under-sinking. In my own mind I had no doubt whatever of the relative value of the two, but as opinions were freely given by Civil Engineers whose experience had been derived from European practice, I may be allowed to state my reasons for selecting the native method, in preference to that so much advocated elsewhere.-

In the first place in throwing expense overboard, it may be inferred that the use of piles in the early days of building originated in the impossibility of laying masonry foundations to the depths that could be reached by Piles, and that as this impossibility (even with all our aids from machinery) still exists under circumstances similar to those with which we had to deal at the Solani; the European Engineer still continues to use piles and to depend upon them for the support of his superstructure. I am not aware excepting in cases to which there is no necessity to refer here, as they are clearly except-
ions

This was written before the use of the Screw Pile was known in India

=ional ones, that either Engineer or Architect trusts to piles where he can sink his foundations to a sufficient depth, and get the security required without them. With the power, therefore, of under=sinking so as to place the Masonry in a position which it would naturally have assumed had I been able to excavate for the purpose, why should I have adopted a method which is clearly an imperfect substitute? Nobody I imagine can argue that a building supported on a series of sharp points, stand=ing on stilts as it were, as is the case where piles are used, can be equal to that where it stands on a broad base as is the result of the block System. On this ground alone I select blocks in preference to piles, and were the Method of undersinking com=prehended in England, I believe that in fully appreciating its advantages, it would in all sandy and light homogeneous soils be adopted in preference to any other sort of foundation. We see in fact in some bridges lately constructed on the English Railroads, an approach to the principle of undersinking, and a recognition of the advantage to be gained by discarding the common pile. The iron Cylinder which is subsequently filled with Masonry; and the different inventions for depressing hollow masses by atmospheric pressure

are

are all tending to the right direction, viz^t. to substitutes for points. Surface.—

Expense however, is a matter that after all is not to be dealt with lightly.. At the Solani Aqueduct we could only have used the largest species of Timber, sticks that would have had to be brought from the forests in Rohilkund on the left of the Ganges with great difficulty, and at great expense; we should have had to construct very powerful Engines at also a great expense; and we should have had to instruct our laborers in a species of work to which they were in a measure unaccustomed. The piling with its supergratings would have cost, including Engines, repairs and all the different contingencies to which such species of work is liable, at least half as much again as that of the blocks, it would have had in my opinion one solitary advantage only and that is that the length of pile would have admitted of our getting to a depth 5 feet below that of the blocks.. Whether, in the face of a Torrent where the subsoil of the bed is in motion to considerable depths, and where the evils of percolation, and the Escape of subsoil ~~are~~ by no means to be left out of Consideration, it would have been worth while to go to a greater

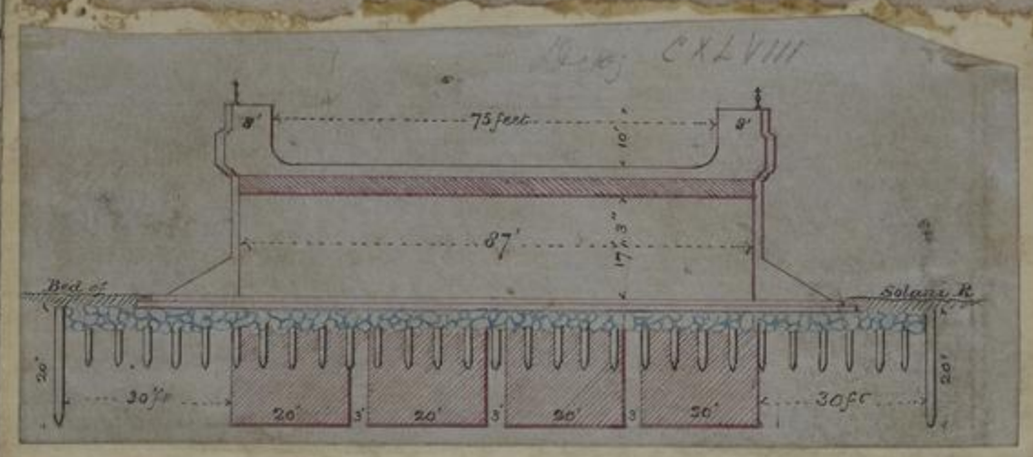
greater expense for a species of foundation most remarkably incapable of offering opposition to these evils, is a question upon which I think there can be no doubt. I have never felt the least distrust as to the selection of the Masonry blocks for the foundations of the Aqueduct, nor would I ever think of piling where such blocks could be used. —

Alder

In boring in the bed of the River the depths to which the Irons were carried did not exceed 37 feet; there were no means at hand for prosecuting these inquiries to any great extent nor did I consider that such were of importance as far as regarded the foundations only. As there was no intention of proceeding to extraordinary depths, I considered that soil lying 20 feet below the surface might be depended upon, and that if the subsoil on which the foundations rested was so far protected as to be kept out of the influence of Current action we were as safe at 20 feet as we should have been at much greater depths; with moderate depths of block Sinking more over, we should be more certain of securing an equability of undersinking. To the depth of 37 feet, nothing was found but Sand occasionally mixed with clay, but in such small proportions that Sand was

was clearly the prevailing ingredient. In practice this was in a great measure corroborated, although many of the blocks have pierced through and rest upon a soil of a much finer consistency than we met with in the boring operations. The blocks, however, may be considered as resting upon sand, protected both in their front and rear by curtains for the purpose of maintaining the said sand intact and free from the action of current either direct in its progress down the River, or indirect in its effect in eddies or movements caused by obstruction. The design will be best understood by a diagram representing the original plan of 1820.

B.71



The above gives the Aqueduct on proportions designed for a much smaller quantity of water, but although extended in width to render it capable of carrying the larger supply of the Estimate of 1845, the details are the same. Here it will be seen that the front and

and rear are covered by Sheet piling with a masonry apron projected to a distance of 30 feet beyond the body of the superstructure. It was supposed that all action of the current would be limited to the extreme boundaries marked by Sheet piling. The after improvement of substituting blocks for these lines of piling has still further increased the value of these pro=tective curtains, and causes which will be hereafter explain=ed, have led to further modifi=cations by which the action of the current is removed to a still greater distance from the body of the work. It will be comprehended by looking at the superficial area on which the base of each of the blocks on which the main building rests, extends; how much this adds to the stability of the foundations.

I now come to the prac=tical method of underpinning the masses of masonry which form the support of the Aqueduct as in the common cylindrical well, a wooden curb (meenchuk) or frame is placed in the posi=tion in which the block is to be sunk; the masonry is then either built up to its full height, or only partly built; it is then permitted to stand over for induration. In my original design each of the cubes was perforated by a cylindrical hole, an

an arrangement which was
altered into Square or octagon
ones, as giving more Space for
the undersinking apparatus
to work in, and as being more
economical in construction.
A common tressel windlass
being placed over each hole,
the Soil is then simultaneously
removed by means of the Dham
which is a large Shovel or more
properly Speaking a Phavra
which is worked either by the
hand at moderate depths, or
by divers at levels below the
Spring water, to this Dham
a rope is attached which by the
aid of the windlass is pulled
up, and the Soil with which
the Dham is laden, is thrown
out and removed. — Professed well
sinkers were not I believe used
in any part of these works, as
in the first place we could hardly
have collected a sufficient num-
-ber, and secondly, it was found
that the System which we adopted
was so entirely our own, that it
was as easy to instruct the com-
-mon laborers of the Country
to work the Dhams and to un-
-dersink the blocks, as it would
have been to break through the
Prejudices of the Professed well
sinkers. — The trade does not
recognize windlasses, but works
the Rope over a pulley fixed on
a support altogether detached
from the well or block. By
this arangement the weight
of both Men and Materials,

by

by no means an element to be lost sight of in aiding the depression of the Masonry, is sacrificed; the, on the contrary, in using windlasses brought the whole superincumbent weight to bear upon the Mass, with at the same time a more economical application of the power; the Sham two that was used on the Aqueduct works, had a Socket attached to the handle end of the blade, which received the end of a long pole by the aid of which we were enabled to work the machine to a depth of 20 feet without the assistance of divers or men actually in contact with the Sham. I describe the system as it existed after much ex=periment, and a great deal of tedious enquiry, the greater part of which took place pre=viously to my return from England in 1818. To this tediousness of experiment the perfection at which the manage=ment of the undersinking arrived, is undoubtedly due, and I believe that to Lieutenant Gale of the Engineers, and to Mr Logan, who was afterwards employed with so much credit to himself at the Dhumowar works, we are in=debted for results which have decidedly been most satisfactory. The way of undersinking the blocks will be much better understood by referring to Plate XXVII of the atlas Vol. 5 p. 6 where

where the work is shewn in progress, and where the detail of construction of the brick laying is also exhibited.

With the removal of the soil from the interior the depression of the block proceeds; it is necessary that this should be uniform, and for this purpose, great attention is required to seeing that the 4 holes are equably worked, and that more soil is not taken from one hole than from another; where the soil upon which the block rests, varies in quality, much judgment is required in working the holes correspondingly with any inequality of depression that may arise from this want of homogeneousness: and, as it will be understood, much practice was required before we arrived at the perfection to which the latter mode of our operations were characterized. As a guide to the well sinkers, strings and plummets were appended to each side of the block, so that a departure from perpendicularity was easily detected. In cases when the simple means above described were inoperative in obtaining the uniform depression, and frequently when the rectangular narrow blocks, were undergoing the process of undersinking when the departure from the perpendicular

perpendicular was very great, apparatus similar to that shewn in Fig. II Sheet No 6 Plate XXVII was used; there a strong frame work with a wide platform at its top, was fitted to the block, so as to obtain the most efficient leverage, the shape of the platform admitted of any amount of load so placed as to reduce the movement to equilibrium, or to force the sinking of the block in the direction that was demanded. This machine was of the greatest possible use in the smaller class of blocks, altho' not required in the larger.

Dawson

The whole of the blocks of which the main body of the building consisted (vide Plate XXVII) has been sunk, with exceedingly small dis-arrangement. The blocks themselves it will be observed are with a few exceptions only, nearly similar; the deviations being in the abutments where they are still (although of different dimensions) of an equilateral form: to this fact may be laid the uniformity and comparative ease with which they were undersunk, in contradistinction to that of the blocks which were substituted for the piles in the front and rear of the aprons as well as to some of those which were appended to the wings. The plan (Plate XXVII A Sheet No 4) exhibits

exhibits this remarkable dif=ference in a very prominent degree. The sinking of these long and narrow blocks to the depths that were contem=plated was in fact, in a great measure, a failure. —

The blocks to which I refer are numbered in the plan 37. 38. 51. 52. 53. 67. 68. 69. 83 84. 85. 99. 100. 101. 115. 116. 117. 131. 132 133. 147. 148. 149. 163. 164. 165. 179. 180. 181. 195. 196. 197. 211. 212. 213. 227. 228. 229. 243. 244. 245. 259 and 260 on the up, and 49. 50. 64. 65. 66. 80 81. 82. 96. 97. 98. 112. 113. 114. 128. 129 130. 144. 145. 146. 160. 161. 162. 176. 177. 178. 192. 193. 194. 208. 209. 210. 224. 225. 226. 240. 241. 242. 256. 257. 258 271. and 272 on the down stream side; their dimensions are

L B D
22'.6" × 6' × 20'
20'.0 × 6' × 20'
15'.6" × 6' × 20'

that is to say it was intended that they should be sunk to a depth of 20 feet. When the commencement was made on the undersinking of these blocks, our men were well practised, and our Establishment was fully instructed in all the different requirements for un=dersinking. The experience that we had gained on the equal sided block nevertheless failed us altogether. I can com=pare the appearance of long lines of these blocks when in the course of undersinking or sunk to a depth of from

7 to 12 feet to a set of drunken men, one block leaning one way, another, another; with an occasional division of sc=centricity in a block going down head foremost: the position which they assumed however, is well shewn in the sheet of plans. Now, independently of the evil of this irregularity of depression which disarranged the consecutive series, and in many cases the close contact of the blocks, which was one of the first desiderata. we failed in the main object of depth- which as designed for the pur=pose of protecting the main body of the building was indispensable: after continu=ing a long line of these rec=tangular blocks, without any hope of success, and at a cost that was frightful, from the impracticability of getting the masses to sink at all when they were much out of the perpendicular; Mr Logan proposed that an experiment should be made with blocks having the same area and shape at the top, but being wider at the bottom; making the block in fact like the frus=trum of a wedge, two of the sides being perpendicular and parallel to each other, the other two sloping upwards: it was supposed that this breadth of base, would retain a certain amount of equi=

libirium

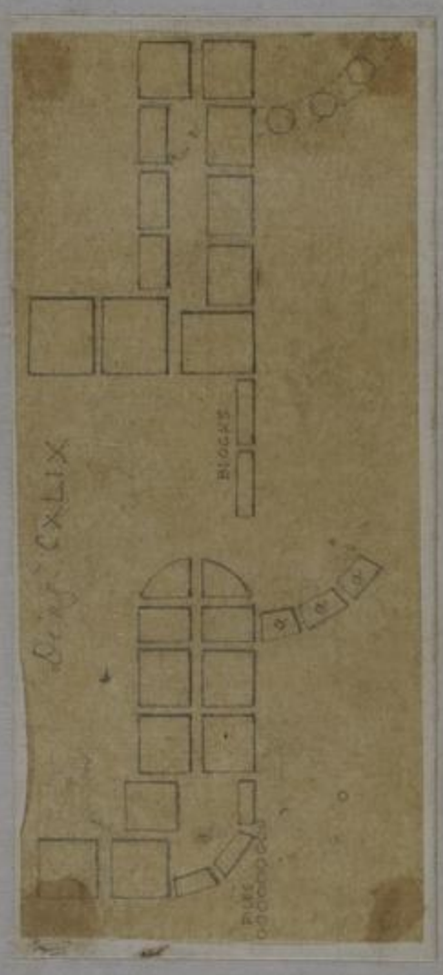
=libium, and that the earth pressing on the sloping sides would by its own gravity fa=cilitate the depression of the block. The experiment was so far successful that all the blocks remaining to be built were constructed on this design, and they appear to have been sunk to their full depth, and without any of the delays and obstructions that attended the rectangular blocks. The plans and sections of the wedge shaped block will be found in the plate above refered to. —

The result of this failure in the curtain or apron blocks, was that the greater portion of those on the right of the River are not sunk to a greater depth than 14 feet, and the depth to which they have been carried is so irregu=lar that I did not think it wise to place any depend=ence upon them; lines of sheet piling, therefore, similar to those for which these blocks were substituted have been driven both in front and rear the former at a distance of 15 ft and the latter of 20 ft feet, the intermediate space between the piling and the blocks being filled with box work loaded with heavy material, and enclosed on its surface by sleepers; the same species of protection in fact which has been given to the

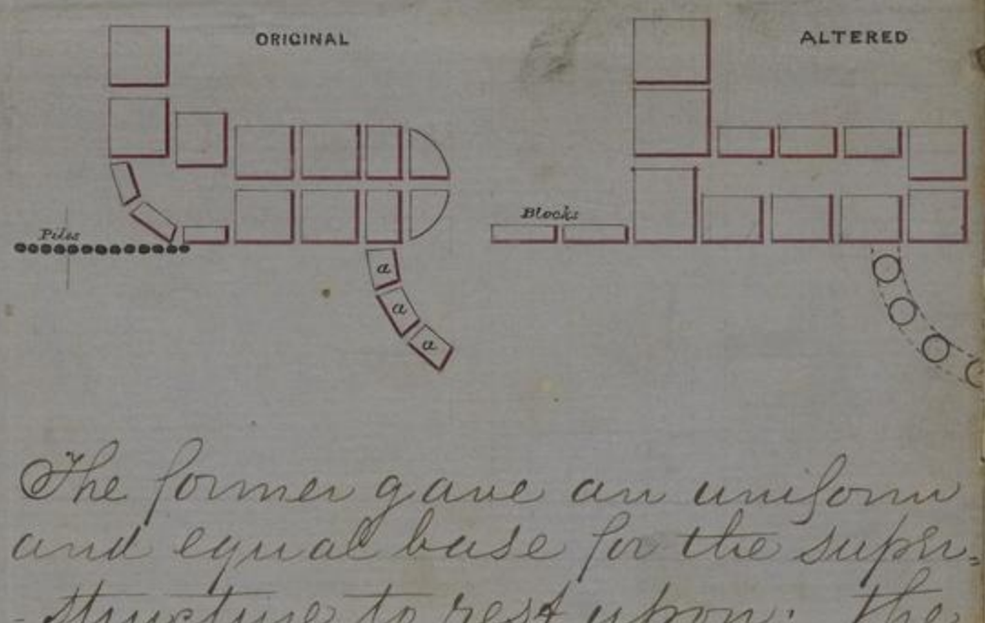
Bridges,

Bridges, Falls and Revetments on other parts of the works The foundation of the Aque=duct, therefore, is protected now in a method that was not originally contemplated, but with a line of demarca=tion against the inroads of the Torrent, that must I consider secure the work from all danger.—

The foundations of the wings were as I said before, altered in as far as both the position and size of the blocks were concerned; the original and the altered design are shewn below:-



Diag: CXLIX.



The former gave an uniform and equal base for the super=structure to rest upon; the latter, although it decreased the expense, deprived the su=perstructure of the above benefit; and as it so happened led us into the difficulties that attended upon the sinking of the narrow block.—

Economy again led me to substitute for the blocks a a, a, above noted, Cylindrical

Wells

Wells, a change which with that of the wing blocks may possibly have led to an inconvenience which will hereafter be described. At any rate both these changes from the original design have naturally led to speculations on their particular merits.—

In the early operations of Block sinking much care was taken in recording the progress of Block sinking. It was found that on a number of Blocks the average rate of sinking of each description of Block in one day, was; —

Size of Block	Rate of Sinking per day	
	Above 10 feet in depth	Below 10 feet in depth
	Running foot	Running foot
16′ × 21′	0·789	0·440
19′ × 10′	0·784	0·378
20′ × 8′	0·623	0·304
20′ × 18′	0·784	0·424
20′ × 22′	0·679	0·251
26′ × 22′	0·638	—

This does not, however, give any correct index to the rate of Sinking of Blocks throughout the work, as there are many and varying elements affecting both progress and cost.

1860

cost. In Appendix O an interesting Paper drawn up by Captain A.G. Goodwyn on this Subject, though not entirely complete, shews in considerable detail the operations carried on under his Supervision; and with this and Lieutenant Yule's results before me, I find that the average rate for each class of Block sinking over the whole of the work, was

Description	Rate per Running foot in depth		
1st Class	16	8	3
2nd Do	16	6	4
3rd Do	9	14	4
4th Do	9	1	6

Every expense being included except that for the Curb frames upon which the Blocks rest.

The use of Strap Iron (or Iron plate) was largely made in the early part of the block building; it gave I doubt not additional strength both in bond and by oxygenation of the Metal to the Cement; its expense however, was very heavy. As the Masonry, both brick and Mortar, was of a very superior quality, I discontinued its use on the ~~expenditure of the~~ Strap Iron which we had in store. The

method

method of applying this Iron in bond is shewn in Fig: 1 Sheet No 5 Plate XXVII together with the Skew backs for the reception of the Arches by which the undersinking holes, refilled with the soil which had been previously taken from them, were covered, before raising the superstructure upon them.—

We will now suppose that the whole of the blocks are sunk to the full depth, that their undersinking holes have been arched over, and that preparations have been made for completing the floorings.—

The blocks it will be observed on reference to the plan were previously to the commencement of undersinking placed at short distances apart, so as to admit of irregularity of depression, and to avoid contact or friction with each other in their progress downwards; the distance between the large class of blocks did not exceed 2'. 3 7/7" that between the smaller ones 2". 11" +

The first thing that was done before a commencement was made to the floorings was to drive piles 12 feet in length, so as to fill up the spaces that existed between the blocks. This was done merely on the outer sides so that as far as possible the external defences might be continuous. The distance of separation between these masses of masonry had in the progress

of

of sinking, become somewhat different to what it was originally designed, but whatever the distance was at this particular period, piles were driven so as to occupy the whole space. On the completion of the pile driving, which divided the whole of the foundations into a series of tolerably compact caissons, the sand and earth were excavated to a depth of 3' feet, & the Spring water being kept down by baling. The whole was then filled in with rubble Masonry, carefully laid and grouted, so that the utmost compactness might be attained, and the upper surface was covered with a flooring of bricks laid edgeways.

I consider that the whole of this work has been very effectively done, and the System adopted by the Assistant Engineer in charge of the building (Lieut Price) of laying the work in, in bits or small portions, so as to secure an effective use of the baling apparatus, enabled him to lay in the Masonry unimpeded by Spring water, and, consequently, to secure the most perfect work.

St Thakan

During the progress of the floorings, a work that terminated during the season of 1853, a commencement was made to the Superstructure. At this time the blocks had many of them been Sunk for upwards of 5½ years, especially those in the Right abutment, and its neighboring piers, and it was

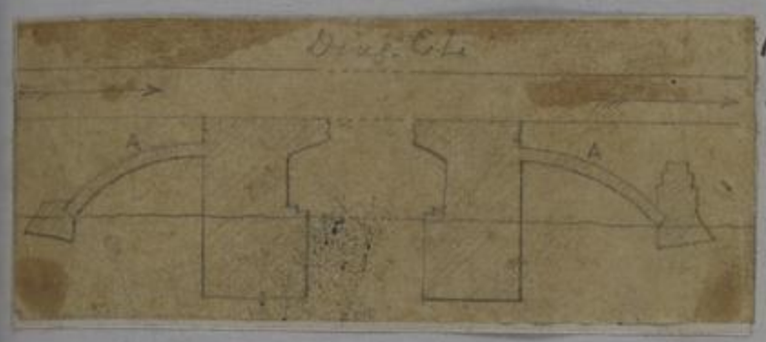
an

an object, therefore, to commence the superstructure on that side; gradually working towards the left, so that the whole of the blocks might have the advantage of the longest available time for settle=ment.-

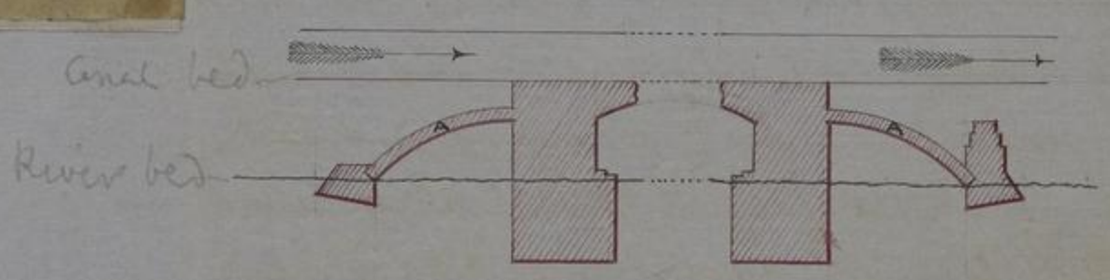
At this period I under=took a careful revision of the details of the superstructure as originally designed and taking advantage of the increase that had been given to the width of the abutment, I decreased the rise or versed sine of the segmental arches, making them similar to those which I had elsewhere adopted, viz: 60° or $\frac{1}{6}$th of a circle, and reduced the thickness of the Arches from 5 to 4 feet.- This enabled me to give increased waterway and to raise the x Spring of the Arch to a height of 12.4.5 feet above the bed of the Torrent, a very great advantage to the capacity of the Channel, as well as to the external ap=pearance of the Elevation. The up and down stream ends of the Masonry Aqueduct connected with the Canal Channel, and the abrupt transition from the ma=sonry flooring of the one to the earthen flooring of the other, was also at this period a matter of much anxious consideration.- Both at the point of ingress and egress of the current upon the floorings, a certain amount of action was certain, and this action could only tend to dis=arrange the bed in immediate

contact

contact with the abutments; to prevent this, therefore, and to remove the current action to a distance, aprons of masonry were placed in rear of the Abutments so that the water could only act within certain well protected limits. The following Diagram will shew the design of this portion of the work.



Diag: C L



A A being the aprons with their abutment blocks. That on the upstream side it will be observed has its block raised to a height merely sufficient to support the arch, whilst the downstream block is elevated. My object in this arrangement was to offer obstruction to the current in its onward movement, supposing that there should be inclination to excavate, and to form holes as might be expected at these particular points where the force of the current was onwards as well as downwards. On the upstream side the action being different, a different remedy was adopted.

The working buildings were carefully worked out in detail, and although not actually intended for the immediate purpose of Mills or Machinery, were fitted with pipes for

for the delivery of water power;
the design included also measures
for denoting the High water mark
both of floods in the Solani, and
of the Canal supply, by appara-
-tus placed on the flanks of the
aqueduct; whilst the wings &
themselves were crowned by plain
pedestals, surmounted by Lions.-

The Elevation of the faces
of the work (with the exception
of the Spandrils being pierced
for Ventilation) remains much
the same as it was formerly.-

The plan that I originally
adopted of building the Super
-structure in two Separate lines,
and of making the Canal
waterway in two separate
Channels, was maintained
in the final revision. The total
width of the work was 192 feet
the piers, therefore, were raised
in portions of 96 feet in width
each, merely touching each
other and free from brick bond.
There were sundry advantages
in this plan, the greatest of
which was its admitting of
irregular Settlement of the
foundations without dis-ar-
-ranging the whole area of
the Superstructure; great facili-
-ties were also given to the con-
-struction of the Arches as by
the proposed plan, the Surface
over which Settlement might
be expected on removing the
centerings was reduced to one
half; whilst the quantity of
ribs and apparatus for build-
-ing

=ing the Arches ~~was~~ were reduced in an equal proportion. In having two Channels for the passage of the Canal Water moreover, we held in our hands the means of of repair without the necessity of closing the Canal. The design (vide plan) admits of the closing of one Channel and laying it perfectly dry, whilst the other affords a free passage to the wa=ter. Another consideration that led me to the division of the pas=sage over this Aqueduct into 2 Channels was the probability that on an extended Surface equal to the whole width, the effect of the continued North Westerly winds which blow transversely to the line of aqueduct, might be prejudicial in causing waves, and a lateral action upon the side walls or Revetments which might endanger their stability. The intervention of a centrical wall would in a great measure Dimagined remedy this incon=-venience. —

It will be observed that at each end of the Chambers, the waterway is divided by piers for the reception of sleeper planks which can be dropped through grooves formed for their reception. The closing of the ends of One of these Chambers, prevents the admission of further water, whilst Small Sluice Shutters connected with Side Channels carried through the Revetments towards the Escapes in the lining building give facilities for carry=ing

=ing off the water which remains in the Chamber after its ends were closed,- The Chamber being thus laid dry, any repair required may be easily effected. The piers above described give supports also for lines of cross communication from one side of the Aqueduct to the other, obtained by the sleeper planks when not otherwise re=quired, being thrown from pier to pier.-

The Spandrils were filled in by cross walls as shewn in the plan; pierced by archways, and opened out to the external air by means of the Circular holes which appear in the Ele=vation on the Pilasters.- These round holes give free ventilation to the whole of the Space connected with the Spandrils, which by means of the Archways above noted, are accessible in all their parts.-

The thickness of the Masonry between the Soffit of the Arch and the Surface of the flooring of the Chamber is five feet, four of which consists of Arch, and the remaining ~~one~~ foot 3/4 of flat brick.- The Level of this flooring coincides with that of the Roorkee Bridge, a part of the design which will be hereafter explained when describing the general levels upon which the Aqueduct has been laid.-

The tops of the Side Re=vetments which are 15 feet in width, are furnished with Single lines of railway in connection with those which

extend

extend along the Embankments
The sides of this Revetment or
roadway, are protected by Iron
balustrades

The above with the Atlas
plans will enable the reader
to obtain a fair estimate of the
design as it existed at the period
when the Superstructure was
commenced. I shall now pro
=ceed to give an outline of pro=
=gress during its construction.

On the completion of the
piers to the full height including
the Skewbacks or impost blocks
on which the arches were to rest,
the single line of railway which
I have described and figured
in Diag CXXXVIII as running from
the Roorkee brick fields to the
Bridge, and from thence on an
inclined plane to the level of
the top of the Cutwaters, had
been gradually, and as the
Masonry had advanced to a
sufficient height pushed across
the Solani, to meet a similar
line which had been made
branching off from the double
rail on the Muhewan side.
The completion therefore of the
upstream Cutwaters, and, con=
=sequently, the line of single
railway, gave us a connecting
link between the Brick fields
at the extreme ends of the Aque
=duct works, and enabled us
to concentrate all our selected
material for arch building on
the field of our operations. The
railway to which I am now
alluding

alluding as connected with the
tops of the up stream cutwaters,
was carried across the 50 feet
bays by the interposition of
two temporary piers in each bay
the width of each being 3 feet, and
its height 10 feet.- Each 50 feet
opening, therefore, was divided
into 3 bays of 14·66 feet in width
each - The rail was supported
on Timbers of 12 Inches Square
or of the common size brought
from the forests, laid longitudinally
across the pier heads.- There was
by this arrangement a free, al-
=though somewhat interrupted
waterway for the Torrent along
the whole line of the work.

The Material for each
Arch was collected immediately
on the spot where it was required,
it was deposited on platforms
arranged for its reception in
contact with the railroad, as
well as on the tops of the piers
themselves: the bricks were of
the ~~first quality~~ best sort procurable
from our manufactories, they
had been in progress of selection
from the early periods of our
Brickmaking, and although
many of them required cutting
and squaring to adapt them
to the particular purpose for
which they were intended, they
were without doubt of a first
rate quality.

Before proceeding to a
description of the Arches, and
their Centerings, I shall take the
opportunity of detailing events
which had occurred at this
period

Wm Rhind

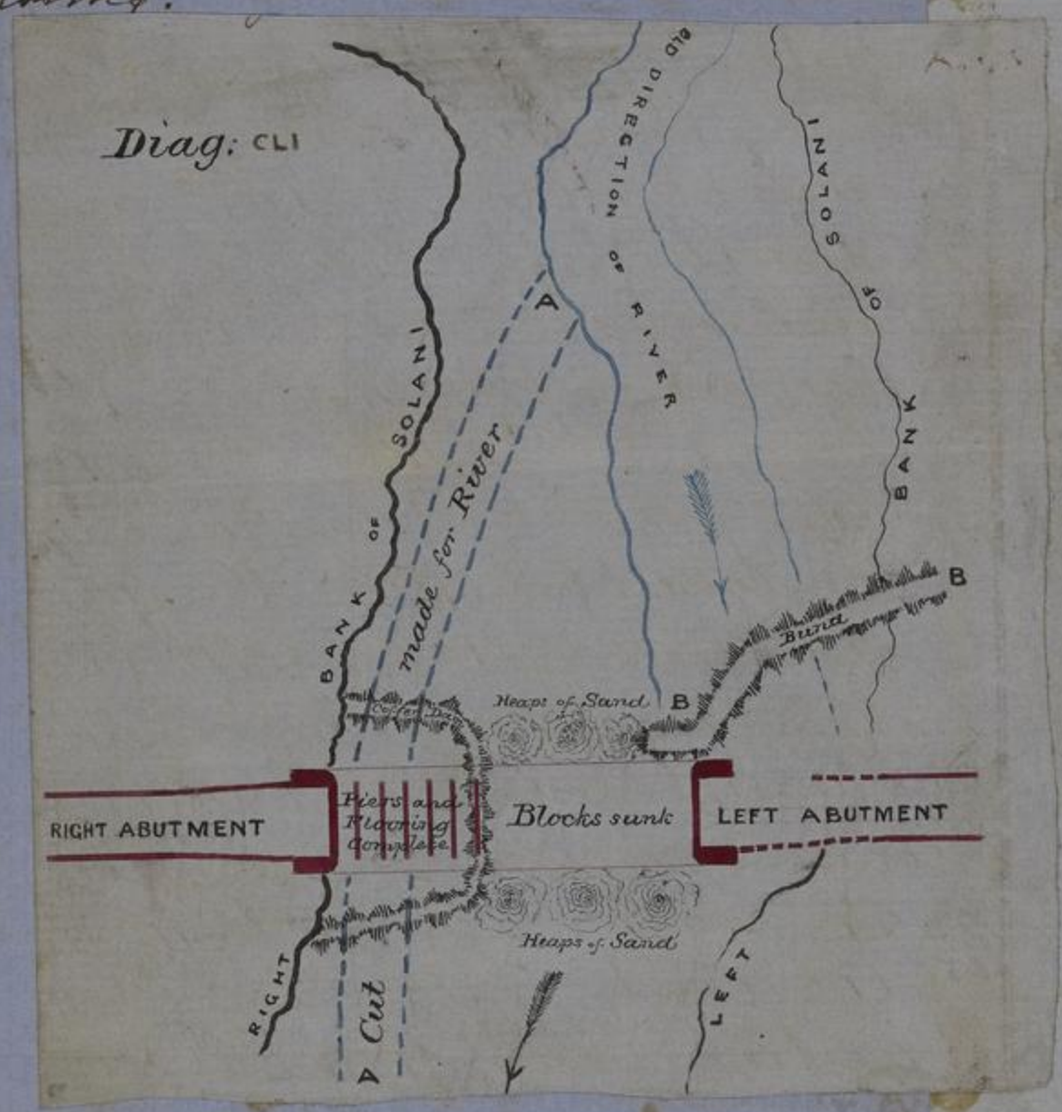
period of the progress of the work, that is to say, from the commencement of Blocksinking up to the 1st of December 1849, or the date when the first brick was laid in the arches.

In January 1848, when I rejoined the works, a Cofferdam or Embankment had been thrown round the whole of the blocks which were in progress; this Cofferdam encircled the right abutment and its neighboring piers, and it was under the protection offered by this enclosure that the work was continued through the rains of 1848, and partly through those of the following year. When the rains of 1850 were approaching, the progress that had been made on both flanks, in the raising of the abutments, and in partly connecting them with the Earthen Aqueduct Revetments made it necessary that we should endeavour to restrict the Torrent to a course bounded by the Abutments. There were no difficulties opposed to the measure, and the only danger that we incurred was from the imperfect state of the Earthen Aqueduct Revetments on the left, which at that period were very incomplete, and in such a state that I considered it necessary to protect them from the Torrent, and from the action of water in its passing down the River. —

At the commencement of the Rains of 1850, the state of

* In describing the aqueduct, it may be useful to note that I use the terms 'Right' and 'Left' with reference to the course of the Solani River.

of the works will be understood from the following diagram, in which I have noted the bunds and cuts which were made previously to the rains of that year for the purpose of protecting the left flank and abutments, and of making the River clear away the Coffer dam, as well as the mountains of sand that had been collected during the progress of block sinking.



The course of the River it will be observed both from the above diagram and from the Map in which the River works are figured, bore at this period directly upon the left flank and upon the rear of the Abutment: there was a considerable bend in this course on the approach of the River to the works, and advantage was taken of this bend to make the

the Cut AA bearing upon the right flank, and piercing the Coffer dam on both sides. The heaps of sand figured above between the Coffer dam and the left abutment were eased off so as to give passage to the water; and the left abutment itself with its half finished Revetments which are shewn by ~~deep~~ thick dots, was covered by a Strongly built Embankment and Spur. As this was the first year that the Torrent had been called upon to pass through our artificial boundaries, its conduct (taking every thing into consideration) was not so capricious as it might have been. On the 5th August 1830 in reporting the effects of the floods upon the Ganges Canal works, I observed that the re=
=sults of the floods at the So=
=lani River have been of ex=
=ceeding interest "Both the abutments of the Aqueduct through which the passage of the River has been effected, had been completed to a suf=
=ficient height, and although the Revetments on the right and left were not entirely finished at the commencement of the rains of 1830, Embank=
=ments and other protective works were so arranged, that the whole of the floods might pass through the water ways of the Masonry work

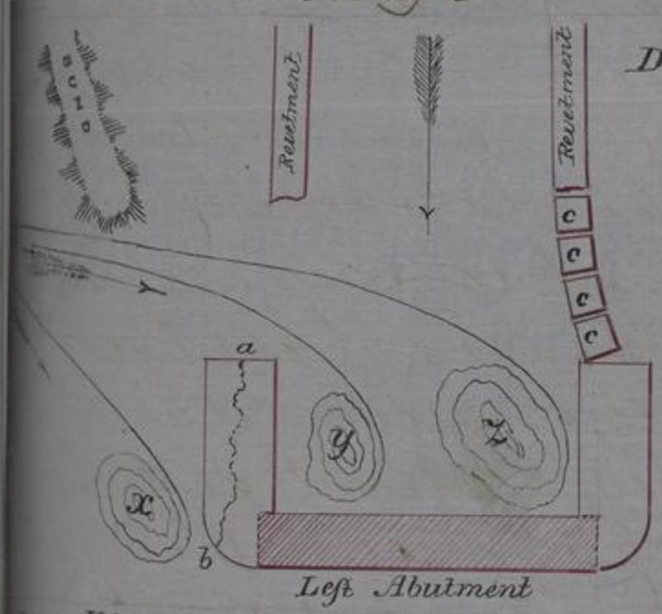
"A Coffer dam had been thrown round the Six

Openings

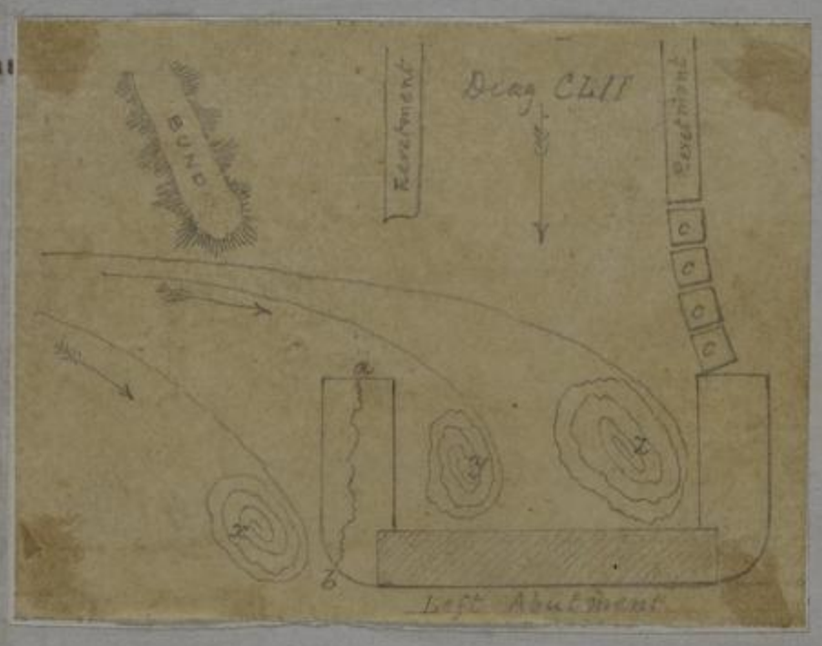
openings and piers on the right flank so that during the rainy seasons previous to 1850, work might be carried on independ-=ently of floods. The object now was to get rid of this Coffer dam as well as of the mountains of sand that had been collected from the undersinking and excavation for the Masonry foundation blocks. It was de-=termined, therefore, that the early floods of 1850 should be the power employed for obtain-=ing this very desirable result, and the Executive Engineer's attention was directed to such arrangement as would lead the water through a Channel prepared for its re-=ception across the Coffer dam and impinging on the right abutment of the work: it was also determined that the main body of the floods should be confined to half the full extent of the water way, or to 7 of the bays or openings of 50 feet in width each as shewn by the above Diagram"

In the same report I state that "the above works have been most successful. Enormous quantities of the collected rubbish have been swept away, and the whole river now instead of bearing on its old course upon, or rather through the left abutment, passes over the site of the Coffer dam, and through the piers which on that side have been

ain that on this, the left side
the Aqueduct, neither flooring
Curtain blocks have been com
ted, so that the current in its
gress was able to exert its full
ce. The absence of connecting
ls from the Revetment to the
tment flank, permitted the
ds to get behind the abutment,
il that I had tried to pre=
t; Nevertheless, taking everything
consideration, the damage
is less than might have
expected" The following
aw shews the directing of
current, and its method of
k when it came in contact
the Masonry -



x.y.z Holes excavated by the Current.
c c c Blocks standing uninjured..
a b Crack on the Wing..



Shaded portion represents
~~portion of~~ the Abutment
ch is connected with the Skew
ks and arches of the building
The Crack was dependant
the Excavation x, and the
~~ination~~ of the wall from the
rpendicular was 1'25 inches
s maximum point - It
s not considered necessary
remove the building which
d at that time been carried
height of 10 feet, but the
hole

been completed". The Engi
in charge of the works repo
that during the time when
floods which effected this cla
were running, and whilst
waters was confined to 3 Fe
there was as much as 12 In
of fall on the length of the
(192 feet) but as the obstru
of Sand gradually dimin
it became level. The water
on the piers to a height of 7
4 Inches above the flooring,
over the sides in a heavy ca
Subsequent to the date abo
=ferred to, and during the
of August 1850, a Succession
floods, gave some trouble,
Embankment on the left
BB Diagram CLI, was was
away, and the water by g
in rear of the abutment, a
amongst the unfinished a
half Sunken blocks of the A
=ments, did some damage
caused a slight settlemen
the left upstream wing of
Abutment. In repo
effects of these floods I re
"that as the blocks which
been disarranged, and th
=sequent crack that has ta
place on the Superstructu
quite independent of the
of the Aqueduct and of
Abutment upon which th
Arches will rest; the inj
is of no consequence to th
work, although additiona
outlay will be required
restore matters to their for
condition. I may further
=

hole excavated at A was filled in with heavy material, ~~strong~~ strengthened by piling, and all other means were taken to reme-dy the defect, as well as to prevent any further continuation of settlement. The rains which usually terminate in September did no further damage. The good that they had done on the opposite flank in clearing away the Coffer dam, and in removing the sand was in-calculable. On the whole and considering the extent of the floods during 1850, we escaped with very moderate injury.

The Cold weather rains of 1850/51 were unusually severe, but the floods that came down the river at this period passed off without any damage & worthy of notice.

The rains of 1851 brought down numerous floods, and tried the Aqueduct at a period when the flanks, the intermedi-ate piers, and the greater part of the floorings were completed From this Year may be dated the passage of the Tolani through the bays of the Aqueduct, and when the Masonry works in connection with the torrent were prepared for its reception, the maximum high water dur-ing the heaviest flood of this year stood 6 feet 4 on the piers; this season passed off without any disarrangement to the works.

On

On the 1st of December 1831, the building of the Arches commenced, and they were carried on without interuption until the 4th of July 1833, when the last arch was keyed.

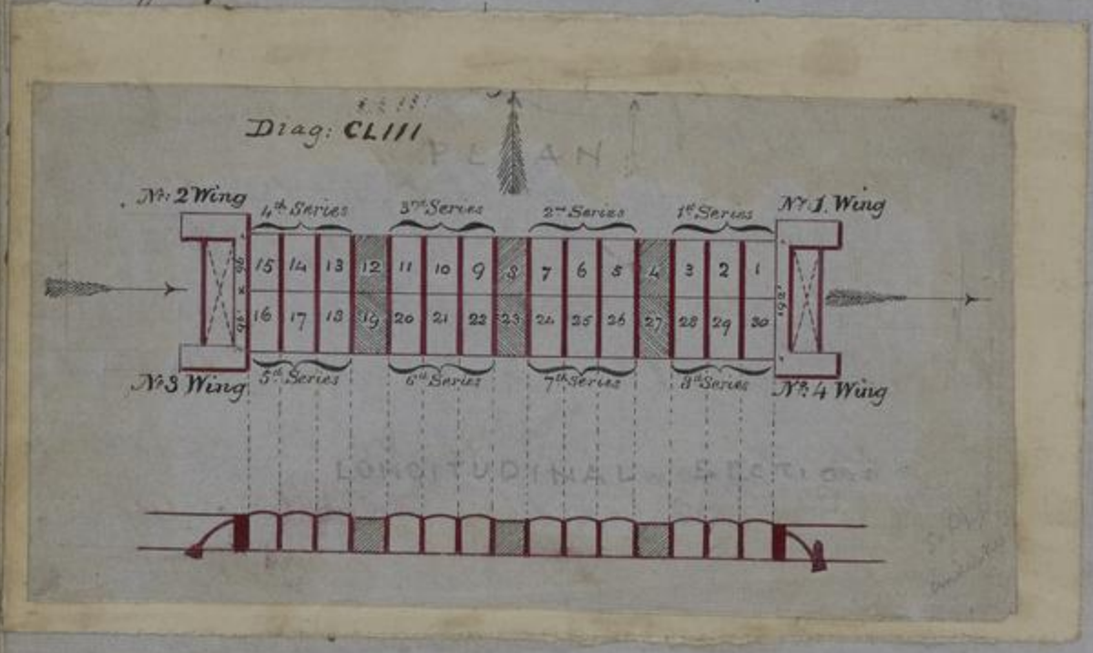
It was my intention at the period when the Aqueduct was designed, to have used Earthen Centerings, which have the Merit of Cheapness and Simplicity, combined with other attributes, which in my idea rendered their use at this point very desirable. The results however, of using Centerings of this description on the line of Canal below Roorkee in building Arches of 55 feet Span, were decidedly opposed to their introduction on the Aqueduct where, although the Span was less in width, the thickness and consequent weight of the Arch were greater. I have in the Chapter on bridges when describing the different Species of Centerings which have been used on the works, entered fully into the Causes which led me to reject these simple Centerings at the Solani Aqueduct; and as I failed altogether in devising any Satisfactory Expedient by which I might preserve the form of the Arch, and at the same time escape from a direct rigidity of Centering, I determined on resorting to the European method of Timber ribs, and with this object Captain Goodwyn of the V

the Engineers the Executive En-
-gineer at Roorkee, commenced
a series of experiments for the
purpose of determining the
best sort of frame that could
be made, at the smallest cost,
and with the least injury to
the Timber that it would be
necessary to cut up for the
purpose - It was our object
as far as possible to take ad-
-vantage of the species of sawn
up wood that was for sale in
the market, and at the same
time that we secured efficiency
to obtain a species of centering
that would interfere as little
as possible with the waterway,
and be quickly and easily
removed -

Keith

The results of Captain
Goodwyn's experiments led to
the adoption [of a species of
centerings which I shall des-
-cribe presently, and to a method
of limiting their number, by
building the arches in detail,
which both as regards economy
in the construction of the work,
and conveniences for passing
off floods during the opera-
-tions,] was of the greatest value
The plan that Capt Goodwyn
proposed was, that by convert
-ing certain bays into abut-
-ments, the arches might be
turned in a series of inde-
-pendent works, for which only
a limited number of centerings
would be required: by adopting
this method, we should be
able to have $\frac{3}{5}$ths of the bays of

of the Aqueduct always open for the passage of floods, and by confining our arch work within moderate limits, we should be better able to econo= =mize our Men and our & Material - The Proposition was an excellent one, and it has been adopted with all the success that could have been anticipated - The arch building, as will be understood by the following diagram, consisted of Eight independent series of triple arches, resting on temporary abutments formed by building walls across the bay adapted to the ultimate support of the Centerings, the spaces between the cross walls being filled in with sand. -



It will be observed by the above diagram that by the division above mentioned, each series is conducted in= =dependently of its neighbours From the circumstance of the Aqueduct on its full width of 192 feet being divided into separate portions of 96 feet each, the

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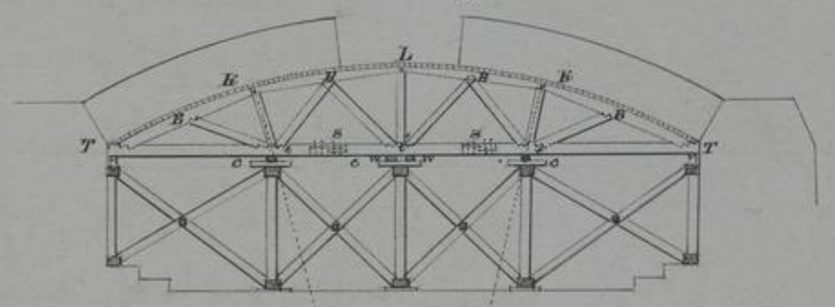
Diag: CLIV

SOLANI . AQUEDUCT

CENTRES

Fig. 1

End Elevation of Centres



Scale 20 Feet to 1 Inch

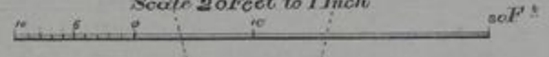


Fig: 2

Elevation Showing method of moving Supports of ribs

Scale 12 Feet to 1 Inch

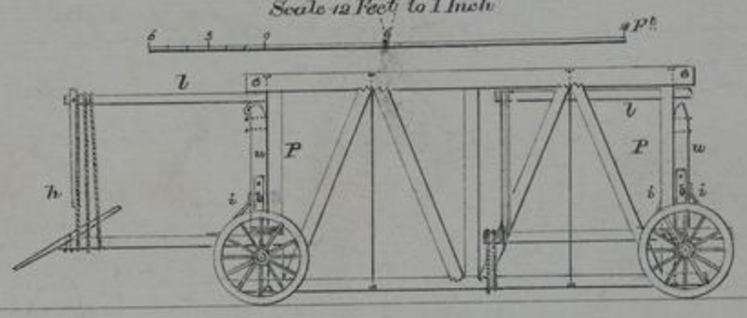
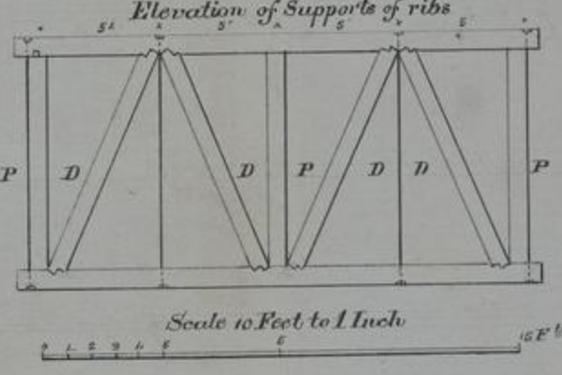


Fig: 3

Elevation of Supports of ribs



Scale 10 Feet to 1 Inch

the whole work resolved itself into an upstream and a down stream line constituting eight sets of arches, or 8 independent series of works: During the pe=riod, therefore, that the building of the Arches was in progress 9 out of the 15 bays, giving a clear waterway of 450 feet in width might always be open to receive floods.—

The construction of the Arches in the series above noted, commencing on the right down stream side was dependent on facilities for obtaining material which that plan preserved, over the other which was open to us, of completing each bay on its full length; the plan adopted also gave us at an earlier period a communica=tion across the Aqueduct.—

The above arrangement having been determined on, the quantity of woodwork re=quired was limited to that for 3 bays, each of which was 50 feet in width and 96 feet long. Captain Goodwyn in making his report to me on the conclu=sion of his experiments, and after having put his centerings in practice, writes thus:—

"After it had been decided that the Aqueduct should be Arched from Shore to Shore in two half widths of 96 feet each, the distance at which the ribs of the centerings should stand from each other was regulated by

by the scantling of the "Brinjari "Kurri" which for the support of an arch 4 feet thick, per=mitted those ribs to be distant from each other 5 feet from centre to centre, without itself suffer=ing appreciable deflection.-

"In designing the ribs having in view the expressed wish of the Director of the works, in which I fully concurred, that the centres should be struck immediately on the arches being keyed, and whilst the masonry was as fresh as possible, a continuous tie beam **TT** Fig: 1 the upper surface of which represented the springing line of the arches, appeared to afford greater facilities for regu=lating the striking, as well as the adjustment of the centres before commencing the Archwork, than supporting the bearing pieces **BB** at once from the floor=ing. To make a tie beam 50 feet in length, however, two scarfs **SS** were indispensable owing to the short length of timber available, and this with the advantage of giving the bearers **BB** as many trussed points as possible, thereby stiff=ening the framing and ren=dering timber of comparatively small scantling available, induced me to give the tie beams five points of support, as the most economical arrange=ment.-

Having these fixed points
T t. t'. t

T t t't and T, four stable intermedi=ate fixed points BBBB immediatly resulted; and the lower surface of the pieces BBBB was divided into 8 equal bearings,- Lines drawn from K to C gave the direction of the ra=diating supports of the bearers, and where these lines intersected the lower surface of the tie beam were fixed the points t t where the supports from the flooring could be most advantageously applied

"No centre can be said to be well designed which is subject to change of Shape whilst being loaded. Had TKL been in one piece the weight of the Arch Masonry in progress from the sides of the Arch towards the centre, as it approached K would have raised up the end L disar=ranging the dressed surface prepared for the intrados of the Arch. The pieces BB were therefore unconnected at K though touching. At L a space of 3 Inches was left between the bearers, thereby allowing the tie beam T t' T to be deflected when necessary, 4½ inches in the centre, the points TT being still fixed, without the ends of the bearers BB coming in Contact at L. It was not supposed that the arches would sink as much as 4½ Inches on the Centres & being struck; had they done so however, and had more room for lowering been required it could have been obtained after lowering the points T which were supported by wedges, with this object in view.

"The

"The supports for the points T t t' t T are shewn in Fig: II. They consist of rough beams dressed on their Outer Surfaces parallel to each other, and of such lengths between the limits of 22 and 28 feet as our Stock afforded. These parallel beams were united by 3 perpendicular ones P P P of strength calculated sufficient to resist the downward pressure at the points T t and t', and the intermediate points between P P P were trussed by the diagonal braces D, each pair of which was of the same aggregate strength as the vertical pieces P. The whole frame was then bolted together by 4 wrought Iron suspension rods as shewn by the dark lines, and became very strong and compact.

"Twenty such frames are required for the centering of each half width of arch (96 feet). They are very massive, but notwithstanding this, they have never been taken to pieces after having once been put together, and are moved bodily in a vertical position by a simple contrivance which I will describe.

"Pairs of wheels with axles and poles were fitted with upright pieces of Timber (Fig: III) set perpendicularly on the axles, about 5 inches from their middle. These uprights are kept in position by wooden braces or shores b, the lower ends of which are fixed on to the axletrees; and by iron braces i, fixed fore and aft, on to the

K K, 497; V. ii. Hill.

the poles. The poles were kept rigid in an horizontal direction at the point of attachment to the axle trees by similar horizontal iron braces at two opposite right angles formed by the crossing of the Poles with the axles, thereby leaving room for the carriages to be backed or drawn close up to their work, which if such braces were given could not be done. The adaptation of levers on the tops of the uprights u will be understood by inspection of the Diagram Fig: III.

"When it is desired to raise the frames which it must be remembered have been left in a vertical position after the removal of the Curved ribs, the levers l are raised by means of the handles h, and their short ends are in the case of the leading Carriage, brought under the ends of the frames C by the Carriages being backed. The upright pieces u having been brought in contact with the end pieces P of the frames, the handles h are drawn down, and the frame is lifted fairly off the ground and hangs suspended from a small Spike at the end of the lever l which serves as a pivot. The uprights u are then lashed to the pieces P (the levers and poles having been previously lashed as shewn in the Diagram) and the Machine is ready for travelling. In the case of the rear Carriage, it is evident that the end of the levers l cannot be got under the end

end of the frame c; this obliges us to use a crow bar at right & angles to the lever l giving a cross lever.-

"The forewheels will now turn in one direction and act like the forewheels of a carriage The head of the Machine can be turned from right to left which is all we require, and the whole runs over the Masonry floor of the Aqueduct with a great ease, carrying its load in a vertical position, and depositing it in the same position on its new Site; after which it is prevented toppling over by 5 Yard Kurries set across each other as diagonal braces, and lashed at their Centres.-

"Above these supporting frames thus arranged and astride of them are laid pieces of Timber 3' x 1' x 5", ccc Fig: I In the case of the central point t' where the amount of lowering necessary to clear the centres from the arch is greatest, and where powerful Screws 3 Inches in diameter with a pitch of $\frac{1}{3}$ of an Inch, working in brass boxes are used; blocks of wood ww sufficiently distant from each other to admit the Screws being inserted when necessary, are set, bearing upon the tie-beams. By keeping the Screws away until they are wanted, risk of theft is obviated, and they are preserved from injury by dripping of water on them whilst the Masonry is in progress. Under the lateral points t t

however

however, pairs of wedges are in=serted, and as the weight borne by them is very considerable, the projection of the pieces c c on each side is valuable, as af=fording the means of applying as many pairs of wedges as may be required; thereby lessen=ing friction on each which renders it difficult sometimes to start a single pair, especially when their ends are bruised.

Boroughs

"After the completion of the masonry the screws are in=serted and are screwed up, their heads working on walls of steel, until the blocks w w can be struck out. A simple kind of guage is applied to each of the points t' t and t' and the operation of striking is then commenced. Correspond=ing points in adjacent ribs are never allowed to differ in level more than $\frac{1}{12}$th of an inch equal to a quarter turn of the screws from each other. Three intelli=gent men are required to su=perintend the lowering of each set of Centres and I pre=fer having an acknowledged difference of level of $\frac{1}{12}$th of an inch between adjacent corres=ponding points, to the greater, though unacknowledged differ=ence that would result if a crowd of people, sufficient to man each point, were turned on to the work, few of whom would have eyes equal to the measurement of a twelfth of an Inch, even if they had ideas

of

of what it was, or what was re-
-quired of them "

I have preferred an in-
-troduction of Capt Goodwyn's
own account of the process that
was carried on, as with the
appended drawings nothing
will be left for further explan-
-ation; the modifications that
experience shewed to be necessary
were comparatively trifling, and
hardly worthy of record. It will
be seen by the table of dates at
which the series of arches were
begun and completed, that
practice rendered the transport-
-ation of the Centering from one
place to another, their fixing,
and preparation for the arch,
a simple and therefore a speedy
operation.

Table Shewing dates at which the Arches appertaining to the different Series notes in Diag CLIII were commenced and completed

Number of Series	Date of Commencement	Date of Completion	Number of days occupied in their construction
1	1st Decr 1831	31st Decr 1831	31
2	9th Feby 1832	29th Feby 1832	21
3	12th April "	30th April "	19
4	19th June "	11th July "	23
5	13th Decr "	2nd Jany 1833	21
6	21st Feby 1833	10th March "	18
7	13th April "	30th April "	18
8	21st May "	5th June "	16
	Abutment Bays		
4	17th May 1832	4th June 1832	19
8	do	do	19
12	21 July "	9th Augt "	20
19	15th June 1833	4th July 1833	20
23	do	do	20
27	do	do	20

Although my great
object in using Timber Centerings
was to avoid the separation of
the bricks in voussoir at the
haunches, an evil which was

so

so conspicuously brought to my notice wherever earthen centerings had been used; we have not escaped from this defect in the Aqueduct, and it is a remark=able fact that this separation small and insignificant as it really is, has invariably taken place at the same distance from the Skewbacks as I have in a former Chapter described as universally occurring in the bridge Arches. For instance, the Engineer reported that "during the building of No. "1 and when the Masonry "had reached to a distance of "5 feet from the Abutment, a "very fine hair crack or sepa=ration on the line of voussoir "took place about 1 foot from "the impost block"; this ap=peared to be universal, and must I suppose have arisen from the yielding of the Trin=jani Kunies on the ribs. I believe that the Arches in the first series, separated more than any of the others; but even here, although apparent when carefully examining the face of the Arch and the courses of brick of which it was com=posed, the separation would not be recognized by an indif=ferent observer. Numerous ex=periments were made in which the relief to the Centering was given both from the sides and centre simultaneously, from the centre alone, and from the sides alone, so that by en=deavoring

=

=deavoring to detect the method by which the material of the arch in its green or moist State might settle down uniformly, without concentrating action on any particular Point. The results of all appeared to be the same and I, therefore, conclude, from the evidence our experience furnishes that these haunch separations are almost inevitable in arches ~~constructed~~ built on centerings composed of ~~[illegible]~~, materials which are compressible by the weight of the arch prior to Keying.

The remedy that was adopted here was the same as that des=cribed in the Chapter on Bridges and figured in Diag: CXII.

In the Arches as I have before said, the best Species of brick which ~~was used~~ was procurable from the Roorkee and Muhewas manufactories, selected for the especial purpose, and when necessary cut and squared, ~~was used~~ was used. The bricklaying was carried on with the great=est possible care under the constant supervision of ~~Lt. George~~ Price, the Engineer in charge; abundance of water was at hand, every Mason having a tub at his elbow, and the smallest possible quantity of mortar was used. When the arch which was commenced from each Skew back towards the Crown, was completed to within 2 Courses of the Keying: the sides were wedged home by the introduction of lines of Planking, so that the masonry with its Cement seams was tightened to the utmost, the Keying

Keying courses were then applied with the hardest brick driven in with Mallets.-

The Centering was lowered early on the morning after the Arch was Keyed; and imme=diately the ribs were removed, or 7 or 8 days afterwards; each Arch was examined and its settlement recorded in a Table (vide Volumes of Tables Appendix P) in which, the actual depression of each arch at the number of points noted in the Diagram is shewn by referring to a fixed Bench mark on the work, and entirely detached from the Arches.-

An abstract from the Ta=ble above referred to shews that the following mean de=pressions resulted on the re=moval of the Centerings of the different Arches.-

Number of Arch	Mean Depression	
	Haunches	Crown
	feet	feet
1	0·1005	0·1905
2	0·0955	0·1940
3	0·1605	0·2710
4	0·0932	0·1785
5	0·1135	0·1950
6	0·1552	0·2475
7	0·2115	0·3180
8	0·0965	0·1650
9	0·0870	0·1445
10	0·0895	0·1895
11	0·1029	0·1987
12	0·0760	0·1290
13	0·0502	0·1290
14	0·0765	0·1419
15	0·0832	0·1530
16	0·0990	0·1875
17	0·0880	0·1975
18	0·1060	0·2335
19	0·0332	0·1325
20	0·0265	0·1135
21	0·0272	0·1155
22	0·0457	0·1355
23	0·0873	0·1509
24	0·0837	0·1460
25	0·0626	0·1260
26	0·1067	0·1708
27	0·0620	0·1340
28	0·0790	0·1550
29	0·0601	0·1395
30	0·0485	0·1305

The arches were not allowed to be touched by superstructure until a period of 6 months had elapsed from the date of their being Keyed.

During the construction of the arches which, it will be understood from Diag: CLIII, was carried progressively from No 1 to No 30, the Spandril walls with their superflooring advanced with an equal regularity of progression; the One being 6 Months in advance of the other Immediately the flooring was completed across the Aqueduct from One abutment to the other, the railroads which I have pre-viously described as having been gradually worked inwards from Muhewar on the North and from Roorkee on the South were connected, by a line laid upon the flooring - At this period, therefore, we had a high line of railroad running on the level of the Canal bed from the Peeran Kulleen digging and the Muhewar Brick Manufactories, to those at Roorkee, together with a single line which, on the lower levels of the Cutwater heads, was connected to the upper ones by inclined planes. The latter was at this period of progress a very convenient siding for wagons used in the carriage of material -

The probability of settlement

=ment occurring during the raising of the superstructure was naturally a circumstance of considerable anxiety. On such an extended area of foundations, connected with soils of various descriptions, it was hardly to be expected that we should entirely escape from a contingency which although not likely to be of serious im=portance, might lead to dis= arrangements even during The progress of construction. In the plan of separating the building into two masses, and the Canal waterway into two Channels, we had as far as they were concerned anticipated the probabilities of Settlement; we were, therefore, not totally un= =prepared for its occurrence.

Early in 1852 when the Right Abutment had been loaded with the first Series of arches, a crack quite independent of the main body of the building shewed itself longitudinally through the wing which is marked as No 1 in Diagram CLIII This crack commenced on the arch of the Waste Channel which was connected with the interior of the wing; it ran back about half way through the building, termin= =ating on the Escape Channel arch which was situated nearest to it; the direction of the Crack is shewn by the line X. X in the accompany= =ing Diagram —

Diag: CLV

Fig: I

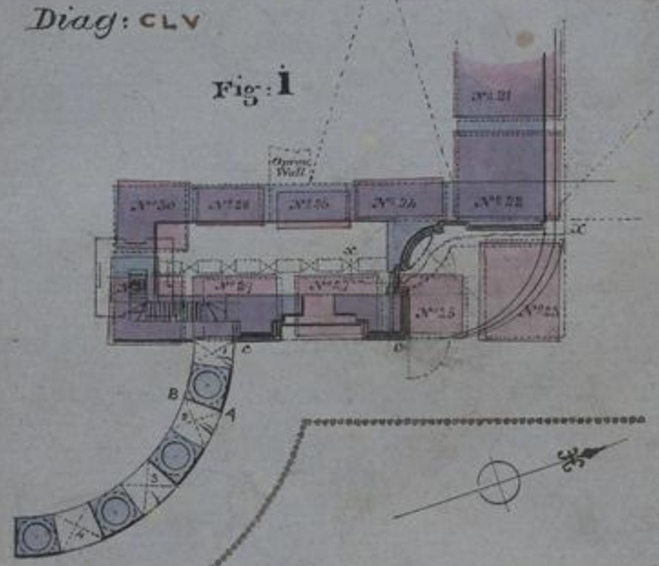
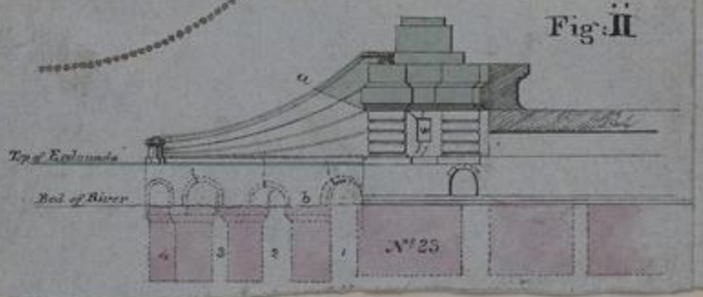


Fig: II



on the line taken up by the Crack the masonry both in Sub and Superstructure was clearly the weakest. Beyond the points x. no signs of dislocation existed, the wing superstructure however, in the neighborhood of the window W, shewed hair cracks as are represented in fig: II. At the same time a slight settlement took place in the adjoining Quadrant, or terminating & Revetment of the Embankments, on which the steps connecting the high and low levels were in progress of building. I have marked in Fig: II the position of the Cracks which shewed themselves on this portion of the building. On the front of the wing c.c. no track of any sort of disarrangement could be detected, but there were certain appearances on the flooring of the Water Channel in immediate connection with the Crack that

led

led me to imagine that the whole front on x, c, c, together with the Quadrant itself had slightly settled forward, that is to say that the mass of building on that side had separated itself from the main body of the Aqueduct. It appeared to me that the blocks numbered 22 and 23 had settled down towards the front, as the flooring on their side next to the crack x' was slightly elevated. The settlement however was so exceedingly slight that the use of the plumb line was insufficient to detect any deviation from the perpendicular, in fact the flooring at x' on the block side being somewhat raised or heeled up, seemed to be conclusive that the settlement had taken place on the side towards the front of the building c.c. The Blocks Nos 23 and 25 had merely by the weight of the Esplanade and the angle of the building upon them, and this weight would not alone I imagine have led to the settlement.

Further

The Quadrant wall foundations were originally designed by me in blocks similar to those on the body of the Aqueduct; economy led me to adopt Circular wells as shewn in the Diagram. Upon these Circular Wells the superstructure undoubtedly presses irregularly, that is to say the vertical pres-

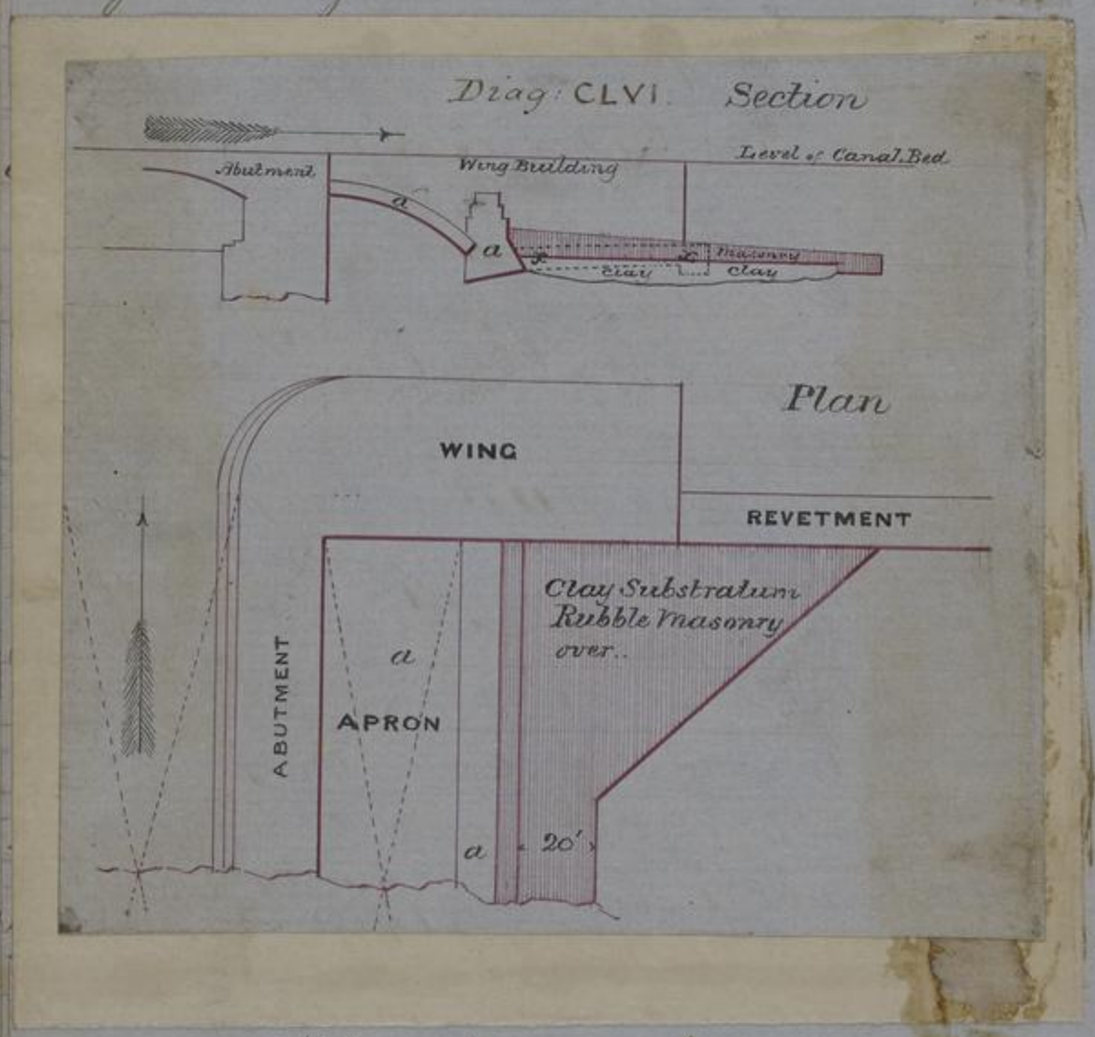
sure

=sure of that portion of the masonry forming the segment of a Circle of which the line tangential to two wells, is the Chord; falls beyond the found=ations. — Whether this can be admitted as an evil sufficient to lead to irregularity of Settle=ment, I am not prepared to say, although from the tenacity of the masonry and from the compactness of form with which it is put together, I should very much doubt it — At the priod however, when these defects were observed, the Quadrant espici=ally was in a very unprotected State, its Convex front was laid bare to a great depth to admit of the front apron being built, and earth had been by some oversight or other thrown upon the Concave side. There ap==peared to me in either case, whether in that of the Wing, or in that of the Quadrant to be no doubt whatever that a slight Settlement had taken place to the wells and blocks The position of, and the abrupt determination of the Crack on the Wing left the whole question, however, very much in doubt; the point was enquired into, and the State of the building was most carefully examined by the Engineers both European and Native who were employed, and who from having Superin=tended the construction and Sinking of the blocks themselves were well acquainted with

the

the work in all its details. It was during this enquiry that I was rather led to regret the alteration that had been made in the original design of the blocks for these wings as repre=sented in Diag: CXLIX it was sup=posed that had the foundations consisted of an uniform series extending over the whole surface the weight of the superstructure would have had a more equable bearing upon the blocks The blocks numbered 24 26 : 27 as it will be seen from the diagram are com=paratively small, and being of the size which practice shewed to be the most unman=-ageable in sinking, had be=-come considerably disarranged especially No 26, which had got altogether out of the line. No 24 and 26 were covered by the apron which I have described and figured in Diag: CL; this part of the wing, therefore, which would otherwise have been in direct connection with the Canal Channel was well and efficiently covered. In advance however, Nos 28 and 30 were ex=posed, I, therefore, to protect this exposed point, and at the same time to strengthen the wings as much as possible on the Canal side, caused into immediate effect the con=-struction of a further guard or protective apron against the action of the water in the Canal Channel when in con=-tact

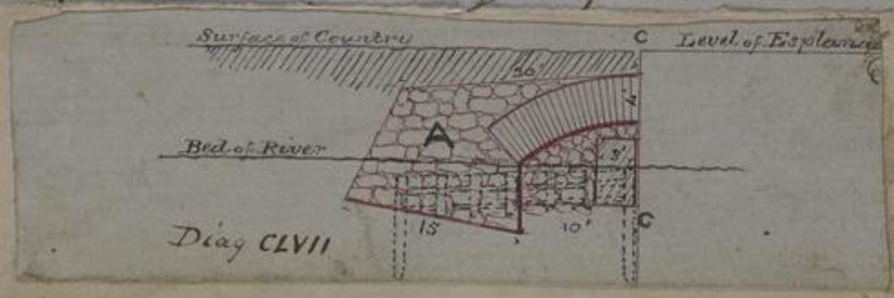
=tact with the wings. The work done at this time will be understood from the follow=ing Diagram. —



The above shews a sec=tion across the aqueduct abut=ment and apron a.a., over which the Canal Current passes in approach to and departure from the Masonry building; X.X. shews a continuation of the apron a.a. which was de=signed at the same time, but which was omitted as an expensive appendage, and under the idea that it might be dispensed with. The action however, of the Settlement above described, rendered it indispensable that no pro=tective means should be left unresorted to for adding strength and water tightness to this part of the Structure Instead, therefore, of following out the original design of extending the apron, as shewn by

by the Dots in fig I, I laid down a Stratum of the best clay pro=cunable, at the Angle near the Wings, giving a covering of rubble Masonry, so as to prevent any probability of the downward action of water + affecting it. The Shaded por=tion of the above diagram, will shew in section and plan the work that has been done. Its main object being to prevent the water which + stands on the high levels from acting injuriously by down=ward pressure upon the floor=ings of the wing buildings.

As far as the above went, very great additional security had been given to the Canal Channel side of the wing buildings. I had now to ad=vert to the opposite or country side, where as in the case of No 1 wing a settlement forward, was to be guarded against. The front of all this work was in process of being piled and protected by boxes filled with heavy material, a few of the piles had been driven, and these piles came into use as adding strength to the work which I proposed to substitute for the boxwork in the wings. The new species of protection will be shewn by the following diagram the boxwork apron as originally planned being represented by dots



Diag CLVII

The large quantity of broken or vitrified brick and refuse material which were collected at the Brickfields and in the neighborhood of the works, enabled me to carry on this with great facility and comparatively with great cheap=ness - Lines of 3 feet Cubes + built of rubble Masonry were laid in contact with, and along the whole line of wing and Quadrant, and as much ma=terial of this desciption as could be obtained was added so as to give weight and Solidity to the whole - Over this a Masonry apron in the form above des=cribed was thrown, the arch bearing with its full weight on the pint CC and upon the convex face of the Quadrant; this arch rested on a very massive abutment A, built of rubble work which was allowed to dry before the Arch was constructed. - It will be seen by the Shaded parts of the above diagram that the whole of this protective apron is covered by the turfed esplan=ade which meets that of the Masonry wing. with the ex=ception of Iron bonds which were used when raising the superstructure of the wing above the level to which it had reached before the cracks were observed, no other measures were taken, and it is supposed that what has been done, will place

place the building out of the reach of further disarrangement To counteract any irregularity in the sinking of the wells upon which the Quadrants are built, and (what appeared to me not at all unlikely) the probability of the sinking of the superstructure of that portion of the building affecting the wing itself; the Quadrant is, although carried up to the wing wall, and in the closest contact with it, built entirely separate; that is to say between the wing and the Quadrant there is no bond in the brick work. By this arrangement action of settlement on the Quadrant will affect that part of the work alone, and not involve in its disarrangement that of the wing.—

A short time after the 5th Series of arches were relieved from their centerings, a slight settlement (of the Substructure I imagine) of that part of the building must have taken place; the action was shewn by the arches coming in contact with those of No 4 Series on the downstream side, whereas they had been built half an inch separate. Not the smallest trace, however, of crack could be discovered, nor did the most strict examination of the piers by the plumb line give any clue to the disarrangement. The

wate

water, however, which was stand
-ing on the floorings and which
rested on the steps at the foot
of the piers shewed a slight
difference of level at the oppo-
-site ends of the Structure.
Such small differences are
barely appreciable, although
this with the fact of the Arches
of the No 5 Series coming in
contact, although they were
built separate, proves that
there was settlement some-
-where or other.

It would appear that
in defiance of the arrangement
that were made for converting
the bays lying intermediate
between the different Series
into abutments, the plan and
Section of which are shewn
in the Atlas plate XXVII Fig:
a slight action was exerted
by the thrust of the Arch upon
the piers in immediate con-
-nection with the Abutment
bays. In stating that such
was the case, however, I con-
-fess that I am not quite
satisfied that such small
differences as I am about to
record can be fairly accepted
as proofs of such action when
the perpendicular surfaces
upon which the plumb line
was used is of plain brick
work. I consider it necessary
however, to state the results
as reported by the Executive
Engineer, whose interest in
this was naturally very great
from the circumstance of his
having superintended the whole
of

of the execution. The first no=
=tice that reached me on the
subject was alluded to in my
annual Inspection report
dated 11th May 1832, but
since the whole of the Arches
have been completed, and the
Centering and Abutment bays
have been cleared out, I have
had the whole of the piers
carefully examined with the
plumb line, and the results
are shewn by the following
Table

	Deviations from Perpendicular			
	At 5 feet from up Stream face of Pier	At 5 feet from Centre of Pier up Stream	At 5 feet from Centre of Pier down Stream	At 5 feet from down Stream end of Pier
	Inches	Inches	Inches	Inches
Right Abutment	1/4	—	—	—
No 1 Pier	1/2	—	—	1/8
2 "	3/8	1/8	1/4	1/4
3 "	—	—	—	—
4 "	—	—	1/8	1/8
5 "	1/8	1/8	1/8	1/8
6 "	—	—	—	—
7 "	1/8	1/8	—	—
8 "	1/4	1/16	—	1/8
9 "	—	1/16	—	1/8
10 "	1/16	—	—	1/8
11 "	—	—	—	3/8
12 "	1/8	—	—	1/8
13 "	—	—	1/8	—
14 "	1/4	1/8	3/16	—
Left Abutment	—	—	—	1/8

Alder

It will be evident that such
small differences can have
no effect upon the building,
but they are (if dependant
on the action of the thrust of
the Arch) of exceeding interest
as shewing the effect of thrust
upon Abutments and the
Enormous power that must
have been exerted in the pre=
=sent case, to have acted in
the smallest degree on such
immense masses. The sepa=
=ration of the courses of brick
at the haunches must not be
confused

confused with the action to which I am alluding: this separation took place during the progress of the building of the arch, frequently when it had reached to 5 feet, sometimes more, from the impost block, and was clearly dependant on the giving either of the ribs and support of the centering itself, or of the kurries and material upon which the intrados rested. —

The above gives in detail the whole of the difficulties that we had to contend against & during the period of our operations, the main body of the building having in fact suffered nothing from Settlement; that on the No 1 and No 3 wings being confined entirely to the wings themselves.

The floorings and Sparandils were entirely completed by the end of March 1854, and the remaining work which consisted of raising the side and centre walls, completing the wings, and making the ogee curves connecting the & Aqueduct proper with the & Earthen Aqueduct Revetment was completed without any difficulty. The design of all this part of the work will be understood from the Sheets of Plans in the Atlas.

The only part of the superstructure that requires especial explanation is the method which I have proposed for laying the Chambers dry, either

either for purposes of examination or repair. — The living buildings were arranged internally in such a way that they may be applicable to Machinery, the power for which is also arranged for by a series of pipes which pass vertically through the Masonry of that part of the building lying in close connection with the Canal Channel. With these pipes, a channel running from the flanks of the Chambers, with its head protected by a stone block and ring is connected. The head of this Sluice or Channel is situated at that part of the Aqueduct in which the expansion of width takes place; it is supposed that its use will seldom or ever be called for, and I have, consequently, avoided any application of apparatus for opening and shutting it, intending that the Shutter should be removed tompion fashion, or (if necessary from pressure of water) by a Crab Capstan. This Channel which is 2 feet wide by 3 feet high, is laid on a slope of 9 inches Now supposing it is necessary to lay one of the Chambers dry, the planks are placed in the grooves at each end, and if necessary made water tight by the usual simple expedients. The Tompions or Stone blocks are then removed by means of their Iron rings; and the water which is enclosed in the Chamber passes off through the Channel

L L, 513; f. iii
Aide.

channel and wing buildings into the bed of the Solani River Each Chamber has two Sluices or Escapes of this sort, one directed towards its upper and one towards its lower wing. The perfect drain-age of the Chamber is effected by means of a cunette or narrow channel slightly de-pressed below the Chamber flooring and with an incline towards the Sluice head. By the means of these Sluices there appears to be perfect facility for laying a Chamber dry, whenever such may be required

In rear of the pedestals which flank the Aqueduct, and which with their superincumbent Lions stand on each wing, the water measuring apparatus, together with the steps of descent from the top of the Embankment levels, to the interior of the living rooms, are situated. The latter are covered by a ~~vestibule~~ or block of masonry, corresponding in character with that of the pedestal itself, they lie on the side of the road of communication which is kept free and open. It is on this road that a single line of railroad is fixed, passing above the top of the flank walls of the Aqueduct, it continues in prolongation along the top of the Embankments On the left Embankment, this line of railroad will connect the interior of the workshops Yard with the works at Dhunowri.

On

On the right a similar line will extend from the Roorkee bridge to some fixed and convenient point beyond the Muhewar Bridge.— The great object of both these lines of Railroad is to es=tablish a rapid means of com=munication, so as to provide the utmost facilities for the passage of wagons; in the first place, for repairs of Embankments; and in the second, for the carriage of Stores and other purposes.— It is chiefly, however, for the pur=pose of carriage of earth for repairs of the Aqueduct Embank=ments that these railroads were devised, and that they should be maintained in perfect order for this especial purpose, is a point of such importance, as regards the Security of the Aque=duct works, that no time nor labor should be spared in se==curing their efficiency

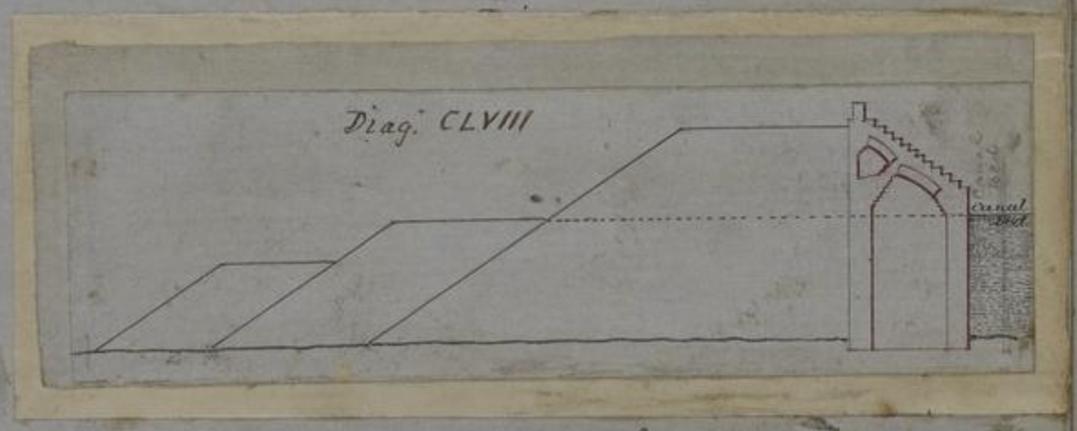
Here, therefore the Questions of Establishments for the main=tenance of these extensive Embankments arises; and in considering the details it must be recollected that the whole of the Earth required must be brought from the sides of the Valley towards the Centre; in fact from the particular cir=cumstances in which the Roorkee buildings are situated with regard to the Aqueduct it appears to me, that Earth can only be procured from Muhewar.—

I consider it to be a law

law that no excavations are to be made on the surface of the valley at the foot and outside of the Embankments. My views at present are strongly opposed to any measures leading to outside excavations; those which have been already done cannot be undone, they were convenient at the early part of our operations, and by smoothing off and sloping the ground in their neighborhood they are at present no very great eyesore. There can be no doubt, however, that in removing the subsoil at this particular point, and by so doing, increasing the difference between the water level in the Canal and the surface of the valley, no benefit can be derived ultimately. We have, moreover, established low patches of ground, the perfect drainage of which is indispensable to the salubrity of the Country, as well as to the appearance of the works. The most efficient means of drainage are offered by nature in the slopes which She has given to the Country, but it will require active measures to keep the ground in order, and in maintaining it free from the rank vegetation which invariably accompanies land of this sort in the Khadir.

The State of the exterior of these Embankments as explained in the foregoing paragraph appears at once to point

point out the advisability, if not the necessity hereafter, of protecting the external slopes especially those in the neighbor=hood of the Torrent, where the Embankments are very high, by a berm or series of berms as is represented in the following diagram; raising the surface of that next to the original Em=bankment to the height of the bed of the Channel, or even higher if such could be conveniently managed: by such an arrangement the Embankments would be strengthened to an immense de=gree, and the contingency of leakage would be dimin=ished to a minimum



This work might be effected by the Establishment maintained for the repairs, and might be considered the Stock work to be carried on at all times when the Men and Wagons could not be employed elsewhere. A better employment could not well be given to them. The prolongation of the steps on the exterior slopes, to meet the extent of berm above shewn would be a very simple pro=cess. In the above diagram where there are 3 tiers of Esplan=ades

=cades, the steps would merely be prolonged to meet them.

The Amount of Establish=ment proposed to be kept up for the repairs and main=tenance of the Aqueduct has been determined on the number of Earth wagons which it might be necessary to keep constantly at work; in cases of emergen=cy daily Labourers could be called into requisition, and for these occasions Spare wagons would be kept in Store.

I propose that similar parties under the same species of discipline as those which are provided for the works lying above the Aqueduct, should be maintained for Aqueduct pur=poses. There should be two of these parties consisting of 4 Mates and 40 Beldars each divided into gangs of 1 Mate with 10 Beldars under him. These parties should have their separate charges clearly defined, one being attached to the right and the other to the left bank.

To each party 15 wagons should be attached, all kept in perfect working order by periodical inspections both of wheels and frame work. Of the above number of wagons twelve would be in constant use; that is to say, telling off 3 men to each wagon with 4 Spare men for extra purposes:- and keeping 3 wagons in store to replace others that might be disabled during the days work.

Besides

Enclosure

Besides these 15 wagons which should be considered as employed on the works, I would recommend that there be 15 others attached to each party but remaining in store, so that on emergency and when additional parties of daily la=borers were necessary for heavy repairs, a total force of 30 wagons might be available for each Embankment

The parties might with advantage be stationed at both Roorkee and Muhewar, in equal divisions; it might be convenient also to keep the wagons at the latter place from whence the main supplies of Earth will be drawn. The buildings; moreover, which now exist at Mahewar, may be use=fully turned to account in giving cover to this permanent Establish=ment.

In the early period of progress I would also make a selection of 20 of the best horses that remain in the stables after the heavy works are com=pleted, for pulling the wagons and aiding the belder parties; as it will be at this period in all probability when from the settlement of the Embank=ments, more work will be required than it will be after=wards. It is, in short very desirable that from the period when water is first admitted every care and attention should be given to the consolidation of

of the Embankments, and this can only be effected by prompt measures for the delivery of earth at those points where settlement is observed.—

The Establishment therefore, that I propose for the Aqueduct is as follows:—

	Mates	Beldars	Carts	
			In Use	In Store
Right Bank	4	40	15	15
Left Bank	4	40	15	15
Total	8	80	30	30

with 20 Horses for the use of the Carts; thus giving 15 for 30 Carts, with 5 Spare ones.—

Time will shew in how far this amount of Establishment may be considered sufficient for the purposes required from it, and whether it may be necessary to retain the Stable department, which is a troublesome and an expensive one. In the mean time, however, I am satisfied that it would be unwise to trust the Aqueduct works to smaller parties. Much requires to be done independently of mere consolidation; the completion of the Slope turfing, the drainage and proper adjustment of the ground on the outside of the Aqueduct, prompt remedial measures in cutting and disarrangement of Earth during rains, are points which if looked after in the few first years of progress, will in all probability give little

little trouble afterwards.

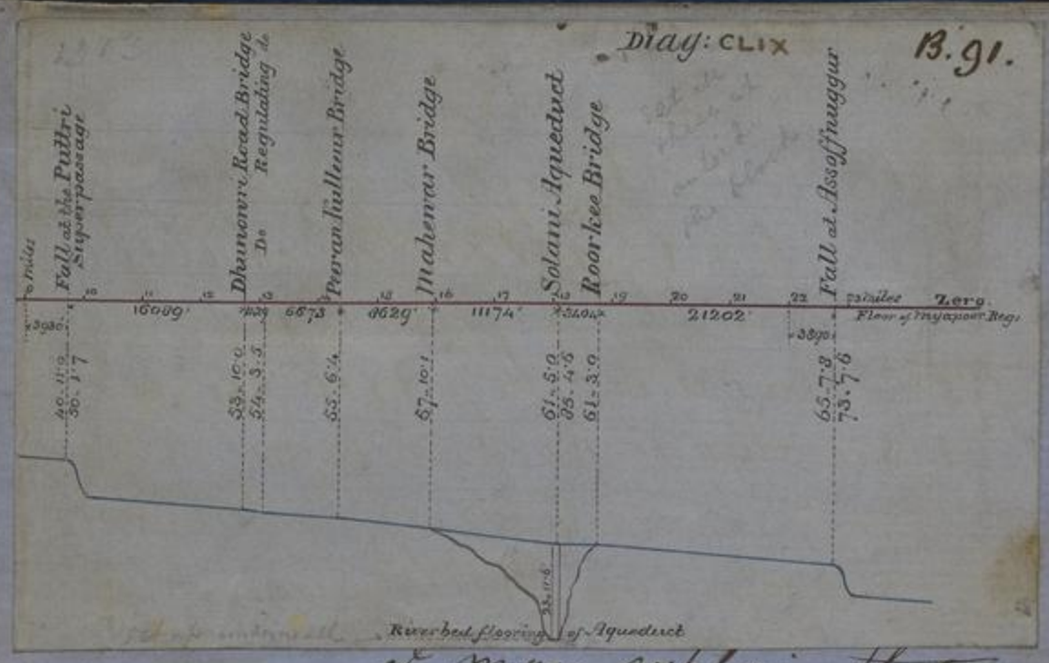
On the Aqueduct itself I have only a few words to say further, viz: that the preservation of the Earth embankments from Trees and jungle, and, if possible, the riddance of all vegetation excepting Doob grass which ought to cover the whole of the Slopes and atleast 3 feet in width of the upper flat in connection with them, appears to me to be very desirable not only for the purpose of preservation, but for the general appearance of the work -

The Masonry Aqueduct will be stuccoed at some future period, when the effects of the water passing over it have been well shewn, and when other more important avocations do not interfere with its progress. —

The levels of the Canal bed as connected with the Aqueduct are the most important part of the whole design - They and the works connected with them, have been most anxiously considered, and from first to last have been the centre to which all my thoughts have radiated

The following section of the Canal bed from the tail of the Puttri Falls and Superpassage to the Head of the Assoffnuggur Falls, is the best introduction to this subject -

Diag:



I may explain that on the whole line of Aqueduct the tops of the Embankments are laid down on a Slope of 1·5 feet per Mile, and the Masonry Revements and other work appertaining thereunto are adjusted to this particular Slope. The Canal bed, however, is on a Slope of 1·25 feet per Mile, so that above the upstream end of the Aqueduct or at a distance of 3 Miles from the Roorkee bridge the Esplanade is 9 Inches higher than it is at Roorkee

Referring to the Section above given, it will be observed 1st that the Slope of the Canal bed from the tail Chamber of the Puttri falls to the flooring of the Roorkee bridge is equal to 1·25* feet per Mile: 2nd ly that the Slope of the Canal bed from the flooring of the Roorkee bridge to the Sill or Wasteboard of the Assofnuggur falls is equal to 1·096 per Mile; and 3rdly that the flooring of the Aqueduct is laid on a level† with that of the Roorkee bridge.

It will be understood from the data above given that the effective Slope on the

Note * Actually 1·2375 by proof Levels
† — do — 2 inches Lower by proof

the whole line viz: from the tail of the Puttri Falls to the head of those at Assoffnuggur is (65.. 7.8) − (50.. 1.7) = 15.. 6.1 in 68600 feet or 1.193 per mile

The tail curtain wall of the Roorkee Bridge is laid to a depth of 20 feet so as, as far as possible, to preclude all chance of evil from the action of retrogression. This Bridge moreover, has been made the point on which a change from a high to a low level has been effected, and consequently, has become in a greater or less degree removed from the effects of the above evil; it will be subjected in all probability to deposits The tendency of the low levels from Roorkee to Assoffnuggur is to throw back water upon the Aqueduct Channel, to modify the declivity of bed, and to save the latter from some amount of attrition.

The Aqueduct flooring (vide Section Diag: CLIX) which is situated at a distance of 3404 feet from that of the Roorkee Bridge, is I have shewn placed on a level with it. The object of so doing in this case was similar to that before described, where the raising of the Sill of the Assoffnuggur Falls had a tendency to throw a deposit on the flooring of the Roorkee Bridge which lies on its upstream side. Were the position of the Aqueduct flooring

flooring renders it liable to deposits from that of the Roorkee bridge, so that what with the floorings of both the Falls and the Bridge, the Aqueduct is not only protected to a certain extent from retro=gression of levels, but there is a tendency ~~to~~ to the formation of deposits over its whole sur=face.—

It will be understood that the true slope of the Canal bed from the Muheewa to the Roorkee bridge, intermediately with which the Aqueduct is situated is 1·25* feet per Mile. The flooring of the Aqueduct therefore, which is situated 4 3104 feet above the Bridge ought to have been raised 8† above it instead of being on. One level had uniformity of slope on the whole line been determined on; there was a great object, however, in de=pressing the flooring of the Aqueduct, so as to remove the action of water in ingress and egress as far as possible from the Masonry, in fact to deprive the water, if such could be done, of all action, and to se=cure a steady and easy flow over the work.—

How far the arangements that I have devised will answer remains to be seen; whether there is any advantage in keeping the Aqueduct flooring depressed, remains to be proved. The whole object of the first has been

Note
* Actually 1·2325 by Proof levels
† — do — ·796 by — do —

been to protect the line of raised Embankment from the effects of Current, and to reduce as far as Could the action of the water in passing from # masonry to Earthwork; that of the Second, is closely con=nected with the same object; but if results should shew the necessity for raising the flooring of the Aqueduct to the height demanded by the effective Slope, the remedy is an easy one, and the addi=tion of the required layer of Masonry may be combined with measures for securing watertightness by the inter=vention of either Asphalte or other impervious ingredients

The following Tables will shew the Amount of water discharged through the Earthen Aqueduct Chan=nel, as well as that which the Masonry Channels of the Aqueduct proper ~~are~~ is capable of carrying at different heights or depths as noted in the 1st Column.- The velocity being estimated at that due to the effective Slope of the Canal Channel from the flooring of the Puttri Falls to the Sill of those at Assoffnuggur, this being

Table I. Earthen or Revetted Aqueduct

	D	R	Velocity V	Velocity u	Velocity U	Area	Discharge per Second
1	11·83	1·28	2·37	0·19	150	192
2	28·40	1·82	3·17	0·47	300	576
3	34·59	2·22	3·76	0·68	450	999
4	45·57	2·55	4·20	0·90	600	1530
5	55·46	2·82	4·58	1·06	750·4	2116·13
6	65·07	3·06	4·88	1·24	903·7	2765·32
7	74·33	3·27	5·15	1·39	1060	3466·20
8	82·36	3·45	5·43	1·57	1219·5	4207·275
9	91·12	3·62	5·62	1·65	1382	5002·84
10	99·67	3·79	5·86	1·72	1528	5866·93
11	106·72	3·93	6·05	1·81	1716·5	6525·825
12	114·84	4·08	6·20	1·96	1888·5	7705·08

Table II. Aqueduct Proper. Masonry Channel

D	R	Velocity V	Velocity u	Velocity U	Area	Discharge per second One Chamber	Discharge per second Both Chambers
1	11·735	1·28	2·37	·19	82·080	105·0624	310·1248
2	23·102	1·81	3·17	·45	166·248	300·9088	601·8176
3	34·081	2·20	3·72	·68	251·137	552·5014	1105·0028
4	44·608	2·53	4·20	·86	336·137	850·4266	1700·8532
5	52·678	2·80	4·54	1·06	421·137	1179·1836	2358·3672
6	64·323	3·04	4·88	1·20	506·137	1538·6565	3077·3130
7	73·567	3·25	5·20	1·30	591·137	1921·1953	3842·3906
8	81·622	3·43	5·38	1·48	676·137	2319·1499	4638·2998
9	90·447	3·61	5·62	1·60	760·704	2746·1344	5492·2688
10	98·643	3·77	5·86	1·68	844·616	3184·2023	6368·4046
11	102·430	3·88	5·95	1·81	927·463	3598·5564	7197·1128
12	111·661	4·02	6·15	1·89	1009·463	4058·0413	8116·0826

We now come to the bed of the Solani River itself, and the works that have been designed and executed. 1st for the direction of its course upon the Waterways, and 2nd for retaining the Torrent upon ~~this~~ course afterwards; ~~which~~ brings us to

Section III. Bunds and Embankments on the Solani River, in connection with the Aqueduct.

From what has been said before, it will be understood that the foundations of the Aqueduct building in addition to the line of blocks which was substituted for that of piling as originally planned, have both in front and rear of the floorings, curtains and aprons consisting of frame boxes filled with heavy material, ~~then~~ and covered with lines of piling. By refering to the plan in the Atlas, it will be seen that the flanks both on the up and down

down stream in immediate con=
=nection with the Aqueduct
have been protected by similar
work, somewhat different in
disposition, but all tending to
protect the ~~Building~~ Guard from any
injurious action from the current when passing
through the waterways. The
Aqueduct building itself,
therefore, as well as its imme=
=diate neighborhood, has been
strongly protected, and as far
as these protective expedients
have been carried, they appear
to be in every way efficient.

From the character of
the Mountain torrents with
which the Canals come in
contact in the upper part of
the Doab, it will not be over
=looked that the bed of the
Solani undergoes constant
change of direction, every flood
cutting from one side the soil
that is delivered elsewhere on
the other, and that here, also, as else
=where, nature appears to have
designed for its use a wide
and extensive valley or khadir,
by the borders of which the
vagaries of the Torrent are
limited.

By referring to plate
XXVII. Sheet 17 Atlas it will be observed
that the bearing of the Aque
=duct across the Valley from
Muhewar to Roorkee laid
at an acute angle with that
of the bed of the River, so that
its course came in awkward
contact with the left abutment
of the work. This evil, which
led

led to the inconvenience as well as accident that I have before described as having happened to the Left wing during the floods of 1850 at a period before the Revetments and walls were completed, could not have been remedied until the Water=ways on the Right were suf=ficiently advanced, to admit of changing the course of the River: and it was not until the Cold weather of 1856/57 or that immediately succeeding the rains when the above inter=ruption took place, that we were able to commence the works in the valley.—

A reference to the Sheet above refered to will explain the steps that were taken for the purpose, better perhaps, than any description that I can give otherwise. Our object was to bring the course of the Torrent fairly and directly upon the Waterways, to get rid of the old bed, the inclination of which was towards our Embankments, and obliquely upon the piers of the Aqueduct. A Series of levels having been taken so as to Shew the contour of the land in immediate connection with that to be operated upon, I carried a line in prolongation of the longitudinal axis of the Right bay upstream un==til it met a curve of the River as shewn in the Map, the dis=tance between the Aqueduct and the meeting of the curve by

by the line in prolongation being 9400 feet. On this alignement the new course of the River was to be directed, and for obtaining this I pre-
-ferred a series of numerous small channels as at a. b. c. d. e. f. g. to one or two large ones as by multiplying the channels the surface of soil to be acted upon by the current was greatly increased, and it was by the action of the current that I proposed to gain a channel sufficiently large for the passage of the water. The work done here consisted in excavating five parallel trenches of 50 feet width each in prolongation of the Abutment and piers, their position being figured in the plate.

The slopes of the bed of the new cuts were to be uniform commencing from the upper bed at B and terminating on the Aqueduct. The slope was in fact 1·276 feet per 1000 feet, from a point on the Cultivaters of the Solani Aque-
-duct 1 foot above the flooring

The Excavated Earth from the Channels a. b. c. d. was thrown on the right; that from the Channel c on the left.

The 2 Channels f. g. for the passage of the Smith Nulla into the Channel c, were each 50 feet in width, with a space intervening of 70 feet in width, the earth Excavated from f be-
-ing thrown on the right, that from g on the left bank.

The

The Bunds which are described in the plan at right angles to the cuts and to the current that was to pass down them were made from sand or soil thrown up from the front of each.

The levels were determined by points which were fixed on the contour; these together with the orders which were given on handing over the work to the Executive Engineer will be seen on the face of the plan.

The transverse section of these 5 Cuts compared with that of a Single Channel with equal waterway, will shew the advantage that the former has over the latter where wear and tear is the object to be gained; it is a very good elucidation of the value also of that element in the formula for discharges through pipes and Channels, consisting of the accurate measurement of the wall, or of the Perimeter in contact with the fluid.

Boroughs

Diag CLX

Fig: I

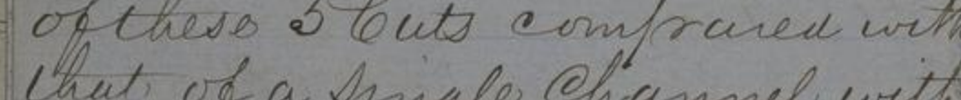
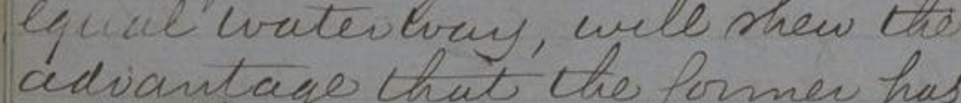


Fig: II



Here in comparing the value of the wall or surface to be acted upon, in the figures above given (supposing for simplicity's sake that the depths are 10 feet) we have in the first case $70 \times 5 = 350$: and in the second 270 only. the discharge in the 1st

1st Case supposing that the walls of the Channel were rigid proportionately less than that in the 2nd. The action of the fluid, however, on the smaller Channels (which would in the above case reduce the amount of discharge) here tends to enlarge and widen the Channel and thereby to gain the object which is desired.—

Economy largely enters into the plan which has been adopted, not only in reducing the extent of excavated Channel, but in rendering that excavation more easy, by shortening the distance to which the earth has to be carried.—

The action of the floods during the rains of 1851, which was the first rainy season in which the Torrents were passed down the Cuts and between the Abutments of the Aqueduct, was comparatively slight; the Cuts, however, did their duty, and the bunds entirely removed the river from its old course. During this rainy season, the piers and floorings of the Aqueduct, and the piers placed intermediately for the support of the railway, were in progress

The first flood was a very early one, and came rather unexpectedly at 4 P.M. on the evening of the 11th June; the 20th of that month being usually considered the time up to which the works were tolerably safe from floods.— The

fine

five Cuts were, however, completed with the exception of small bars across 2 of them left until the last moment for the purpose of cross communication. The Torrent came down through the Cuts, leaving the Old bed of the River high and dry, and not interfering with the bunds in any way. The water of this flood rose 4 feet above the flow=ing.

On the 9th of July a flood 3·75 feet in depth on the flooring passed off without doing any damage, although shewing an inclination to Cut on the right, upon which the Current had made a set. The Executive En=gineer, therefore, stopped up the heads of the 2 Cuts a and b, as well as the 2 night water ways of the Aqueduct. During this flood it was supposed that at least 4/5ths of the volume passed down the above 2 Cuts The bunds which were made were raised merely above the Surface of the ground, so that they might be topped by water rising above 6 feet. It must be understood that at this pe=riod the flank protections to the abutments on the River side had not been built, and that it was of the utmost im=portance that these parts of the work should be removed from all danger.

The Upstream piers both of the main Aqueduct, and for the support of the Railway

on

on the upstream face were at this time completed. On the 10th of July, and in reporting the above flood, it was stated "that our cross communication "with the two banks is now "complete for foot passengers, "and the railway will in a "few days be laid from Abutment "to Abutment. The work re- "maining, however, to complete "the piers on the down stream "half of the Aqueduct ready "for arching is very consider- "able".

W. Mahon

The state of the 5 Cuts after the above two floods was not much changed, the edges of the two right ones had be- -come serrated or broken into Ravines; in some places the earth had fallen in, 10 feet from the original digging, but the average was not more than 4 or 5 feet, and at many points the banks were hardly cut away at all.

On the 14th July, a flood 4 3/4 feet above the Aqueduct flooring passed down the river. The 2 right cuts having been bunded up at their heads, all the water came down the 3 others c, d, e. Al- -though, moreover, the 2 right waterways of the Aqueduct were bunded, not the slightest ac- -tion was observable on the right abutment. This flood was not sufficiently high to test the measures that had been taken, but the results as far.

far as they shewed themselves were satisfactory.—

During this flood, work was carried on as usual on the superstructure, although water was flowing through the 11 Centre Arches.—

The effect of turning the River from its old course appeared at this time to influence the movement of the Current above the head of the Cuts at the point **B**. The stream began to abandon the turn or deep loop on the right bank above the Cuts and to come perpendicularly down on the alignement of the Centre Channel. We found it, therefore, desirable to ease off the sides of the Cuts in places where the natural soil would not give way, as this supersoil acted as a most perfect check to abrasion, which instantly took place on its removal.—

On the 22nd of July, a fleet flood passed down without causing any inconvenience, and was as easily disposed of, as the former ones. The effect of this flood placed at rest any doubt about the efficiency of our Cuts and bunds. The water passed down 3 of the Cuts at the head, and broke through the bund at the head of Cut 6, not owing to its having topped the bund, but to the action of the Current on its face.

Up to the termination of the rainy season of 1851, very little rain had fallen about

Roorkee

Rookee itself, the Solani floods originates entirely from falls of rain in the Sewaliks. The results of our works however, were very satisfactory especially the Inlet of the Imli Nulla with its bunds, at and in connection with which, I had anticipated much trouble.—

Borrowed

Previously to the setting in of the rains of 1832, the series of Arches marked in Diagram CLIII as 1. 2 and 3 had been completed, and the 4th was in progress during the months of June and July. On the 9th of August —" — or on the day of completion of the No 12 Bay, the whole of the down stream half of the Aqueduct was arched in. We at this time, therefore, began a new period in which the floods had to act on the work with the down stream half loaded with arches, and the upstream piers and railroad supports acting as obstructions to the current.—

As in the season of 1831 the floods were earlier than usual; a small one came down the River on the 15th of June, without doing damage of any great importance, although it reached the works when the bunds were under repair. On the 27th of June, a flood of 7 feet on the flooring, and on the 4th of July one of 8 feet, passed through the Aqueduct. These

(M. M. 529. V. 2. P. iii.)

were

were heavier floods than we had experienced, but they passed off without doing any damage although at the time they were running, the 2 bays on the right, as well as the 4 on the left, connected with the Arch building of the 4th Series were entirely closed. I am desirous of entering into the fullest detail on these matters, as the position of the works during this, as I may call it, initiatory period is of much importance and interest connected with the value of the waterway of the Aqueduct. For instance, on the flood of the 4th July, there were 6 out of the 15 bays closed, besides the obstruction given to the free passage of the water through the remaining 9, by the interposition in each bay of 2 piers for the support of the railroad.

The effects upon the bunds arising from the above floods were as follows:- the main or leading bund **D**, situated at the head of the Cuts, and which crossing the old bed extended some way into the Country, was broken at its intersection with a hollow at a point considerably to the left of the River; as far as fracture went, this was the only bund that suffered.

The retrogression of levels which was necessarily attendant on the new Cuts had acted considerably

considerably. The beds of the Cuts which were level with the natural soil at the point guarded by the "Nulla bund" were at this time 3 feet below their Embankments; and per-=pendicular falls or drops had established themselves elsewhere. The same was in operation on the 2 Cuts f. g. connected with the Imli Nulla; the Eastern one g being about 2 feet deep-=er than it was originally ex-=cavated, the western Cut f was little affected by the floods

On the 21st of August there was much rain and the Solani rose to a height equal to that of the 4th of July, or 8 feet on the Aqueduct flooring. These heavy floods did great good in clearing away the remaining Sand that existed in the neighborhood of the works, from the block sinking and flooring excavation. After the flood of the 20th August, the main set of the Current was straight through the Centre Water way, and from thence straight against the Old bank opposite the village of Mullikpoor: the deep water running close under the bank on the opposite side to where my Estate is situated.

The rains of 1832, there-=fore, passed away, not only without doing damage of any description, but in giving one increased confidence on the works on the Solani valley,

as

as well as in the sufficiency of the waterway of the Aqueduct, and of the protective works connected with both its flanks and its foundations.—

During 1833. the rains were by no means continuous throughout the season; in the early months there was a good deal with much intermission to work, but latterly hardly any rain fell at all;- there were, however, some heavy floods, which occurred at a period when the Aqueduct from having 7 of its bays closed, stood a still further test of its sufficiency for all purposes required.- The last Arch was keyed on the 1st July 1833.- previously to which a flood ~~which~~ came down on the 15th June, and stood 3¾ feet on the Aqueduct flooring, during which the following bays (vide Diagram CLIII) Nos 4. 8 and 12 were shut. Now, this was more trying than on any other occasion, from the circumstance of the centre bays of the Aqueduct being interrupted; No injury however arose either to the bunds or to the Masonry work, and the cuts became very much enlarged.- The result of this years rains was in fact more satisfactory than that of the years which had preceded it, and added, if anything was required to do so, to the confidence which I had already expressed of the stability of the Solani works

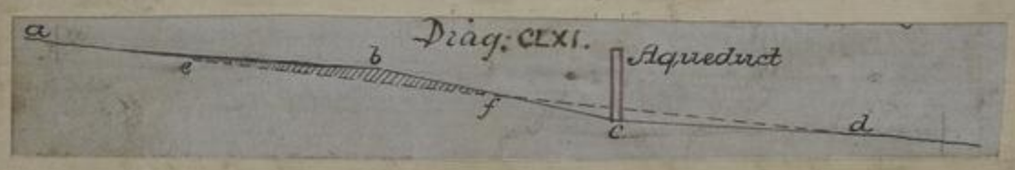
I have not attempted to describe in all their details the different additions that were made to the bunds &c during the 3 years since the Torrent was placed on its new channel Some of the bunds originally proposed were omitted, others have been extended both in length and increased in proportions; low ground on the right and in the vicinity of the Aqueduct itself has been protected, and much improved by detached works which circumstances shewed to be necessary; and the greatest attention has been given to the permanent security of the whole.—

Plate XXVII Sheets 17 and 18 of the Atlas will shew this detail, and explain the changes that have been made during the continuance of our operations, as well as the effects upon the Cuts by the action of the Current during the rains of 1852 and 1853.—

The true slope of the bed of the Solani River as effective upon the Aqueduct flooring's was determined very carefully by me in 1854, by a series of levels taken on a length of 10 miles - 8 of which were above and 2 below the site upon which the work has been built. On the above length the total fall was 50·89 feet or 5·08 per Mile.—

It will be understood that by the change of course and

and by the straight direction upon which the new cut has been brought to bear upon the Aqueduct, the natural regimen has been disarranged, and that as I have shewn elsewhere the straight cut which brings the water upon the upstream face has a slope of 6·737 feet per Mile, an excess of slope which is uniform on the whole length of the cut on a distance of 9070 feet. The rapidity of the slope thus given to the bed on its approach to the work has a favourable tendency towards the establishment of deposits on the flooring of the Aqueduct, and to protecting the tail from the erosion which an uniformity of declination of bed would have led to.— The effect I imagine here, will be similar to that which I have before explained, as having arisen in all cases where by a change of slope in a Canal bed, a rapid descent delivering the water upon a line of a reduced fall, the slope of which is insufficient to carry the water forward on the same velocity with which it arrived at the point where the change of level took place. — For instance in the bed of the Solani to which our attention is now directed, we have the bed in connection with the floorings of the Aqueduct similar to that shewn in the following diagram.—



Diag: CLXI.

a. e b and c d are parallel to each other and on a slope of 5·08 pr Mile; the intermediate portion b f. c being on an in=creased declination of 6·737'-

There can be no mistake whatever on the results of this arrangement, they have in fact been from the period when the water was first poured down the cuts in constant progress towards completion; rapids and abrupt descents have been establishing themselves in the bed of the cuts, with a retro=gression of levels, the abraded matter being thrown in advance. in other words the shaded tri=angle in the above section a. b. f is undergoing abrasion and removal, whilst the soil so removed is thrown on the floor of the Aqueduct. The re=sults of the action which I imagine to be taking place ~~is~~ are clearly exhibited above where the dotted line points out the surface of the true bed of the River as it will ultimately appear, when the water has fixed for itself a regimen de=pendant on the slopes which we have given to the bed.

Laying aside therefore the fact of the great advantages derived to the work, by bringing the Torrent to bear directly upon the bays, by which the protective measures for the flanks, and the discharge of the bays themselves have their fullest benefit; the foundations of the Aqueduct

itself

itself derives the greatest of all possible protections from the results which I have above described, of deposits.

The slope of the River although comparatively small when placed alongside of that of other torrents with which we have had to deal, is still considerable. I am of opinion however, that from the great extent of waterway which has been given to the passage through the Aqueduct, and consequently to the diminution of obstructions to the deposits on the flooring reducing the action of the current in its passage during floods possibly to a point lying above the masonry floorings themselves; and to the superficial character of the River on the down stream side, with the junction at a somewhat acute angle of the Rutmoo Torrent about ½ Miles below it; that a retrogression of levels upon the Aqueduct tail is not to be anticipated My best endeavors, however, have been to provide against a contingency of this sort by a consecutive line of piles driven close together at a distance of 20 feet from the masonry floorings, the intermediate space being filled with box work and heavy material, confined in its position by sleepers; an arrangement that will be understood by an inspection of

the

Withdrawn

the plans—

Shewing as I do the retrogression above alluded to as improbable, I have had no hesita-tion in carrying out the cuttings in prolongation of the abutments on the down stream side of the bays, so that the current may trim fairly off, and not be inter-rupted by the turn which the Old course of the River gave it immediately on its escape from the waterways - A great object that I have in doing this, is to keep the water at a distance from the Rookee side of the val-ley, and to form the border resting on the right of the letters a' a' a', into a raised Esplanade smoothed off and turfed, in continuation of that which now exists on the right of the Old River - A work of this sort can be easily done by warping, and making the Torrent deposit silt on the flank that requires to be raised - The improvement will be an immense one to the Station and can be done grad-ually by the aid of the Estab-lishment which must be maintained for the purposes of the Aqueduct -

In Estimating the theoretical, as I have already given the efficient practical value of the waterway of the Aqueduct for passing off the floods of the Solani, I shall treat the subject in the same way that I have done the Superpassages - i.e. by Estimating the

the area of the Catchment basin which depends upon the Aqueduct for its relief from drainage, under assumed falls of rain over that Catchment basin —

Supposing, therefore, that 12 Inches of rain fall over the whole Surface, viz. 216 Square Miles in 24 hours, the total quantity of water that had fallen would be

$5280^2 = 27.878.400$ cubic feet in 24 hours
1.161.600 do in 1 hour
322.666 do in 1 Second

therefore the discharge per Second would be thus: —

$322.666 \times 216 = 69695.856$ cubic feet

I see no necessity for entering into the variety of causes that would interrupt the regularity of the above discharge, nor the probabilities of heavier falls than 12 inches in the time given: for this reason, that although the Rain guages do exhibit occasionally a greater amount of fall, even as high as 5 inches in one hour, such falls are limited to small areas, and arise in nine cases out of ten from the breaking up of a detached mass of cloud hanging over a limited tract — As far as my experience has gone I believe that investigating at the rate above given, and over an area as above described, I am in excess of any actual fall of rain that has ever been recorded; and that an average fall per square mile of 322.666 cubic feet per Second as occurring upon an area

area of 216 Square Miles, is a fair and liberal allowance to provide against.

The following Table explains how the above discharge will be met by the waterways of the Solani Aqueduct. The 1st Column shewing the depth of water and the last, the actual discharge through the 15 bays of the volume due to that particular depth

D	R	Velocity V mean	Velocity u Surface	Velocity U bottom	Area	Discharge pr Second 1 Opening	Discharge pr Second 15 Openings
1	11·424	2·308	4·537	1·079	40	112·320	1684·800
2	20·817	3·813	5·856	1·770	85	324·105	4861·575
3	28·920	4·503	6·760	2·246	135	607·905	9118·575
4	38·268	5·202	7·673	2·731	185	962·370	14435·550
5	47·000	5·775	8·294	3·256	235	1357·125	20356·875
6	55·161	6·269	8·940	3·598	285	1786·665	26799·975
7	62·813	6·688	9·486	3·890	335	2240·480	33607·200
8	70·000	7·067	9·985	4·148	385	2720·795	40811·925
9	76·764	7·404	10·304	4·504	435	3220·740	48311·100
10	83·143	7·709	10·693	4·725	485	3738·865	56082·975
11	89·167	7·986	11·069	4·933	535	4272·570	64087·650
12	94·868	8·257	11·357	5·157	585	4830·345	72455·175
12·542	97·824	8·365	11·485	5·295	612·083	5120·074	76801·110

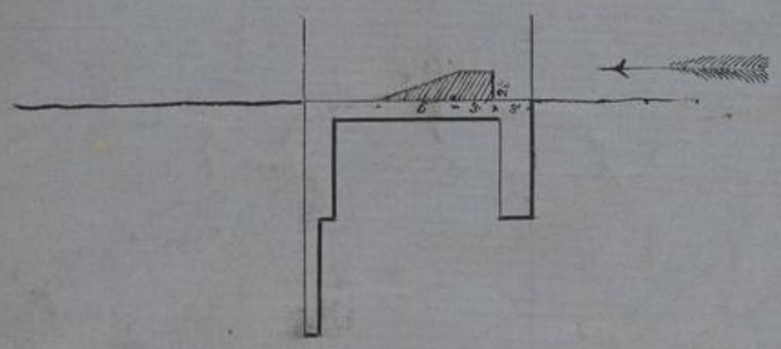
I have retained the slope at 5·08′ per Mile, that being the natural one of the River; the modifications which have arisen from the new Cut above the Aque=duct, would if anything rather tend to increase the velocity than otherwise and consequently, to increase the discharge.

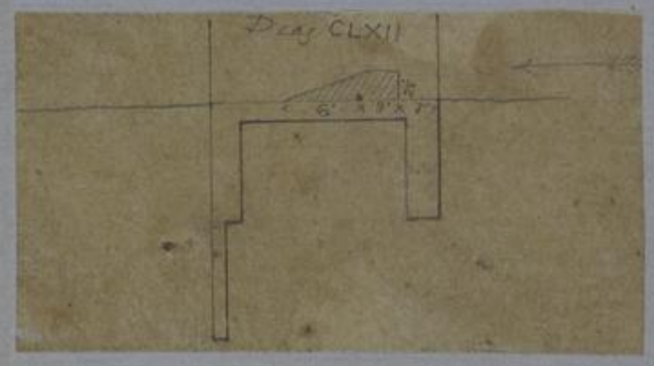
It will be seen from the table that high water on the Weirs equal to 11½ feet in depth would give a discharge very nearly equal to that which I have estimated as a Maximum whereas the full value of the waterway which I consider to be up to the Spring of the Arch or 12·542 feet above the level of the

the flooring would admit of a free discharge equal in amount to 76801.110 Cubic feet pr. second

In concluding this Chapter I may add, that previously to turning the water over the Aqueduct, a temporary weir or overfall of 30 Inches in height was raised on the flooring of the Roorkee bridge; this was built in each of the bays of brick work, its section being as follows:-

Diag: CLXII





The object was to retain back water upon the Aqueduct, to save the bed from wear during the early period of its being used, and to give efficient aid to consolidation. Subordinate to these it gave additional depth of water for boats during the period when the boulder stratum was in progress of being laid down

The bar of masonry can be removed in half an hour or even in less time than that, should it be found to be unnecessary, or conducive to injury. It will be removed entirely when the Aqueduct bed is properly adjusted with reference to the lower bays of the Aqueduct through which the torrent passes

passes, it would be desirable to see by experience whether Overfalls or bars like those above mentioned might not be built on the flank bays, or in those next to the Abutments. These might be built to the height of heavy floods, say half the height of the pier or $\frac{12.457}{2} = 6.228$ feet above the flooring - The advantage of these arrangements would be that they would protect the flanks, by keeping the current at a distance from the abutments in all common floods; in all in fact that did not exceed 6.228 feet in height The effect would be to throw a long spit of sand of 60 feet in width on each wing, which would by no means improve the appearance - It is evident however that if the water can bear it, the proposed falls in the flank waterways will give a very efficient cover and protection to the Abutments.—

Jan 6. 54

1839.

CHAPTER X.

Excavation of the Canal Channel.

The general design upon which a Canal for Irrigation is projected, has been sufficiently explained in former Chapters; in this place, therefore I shall confine myself to the method adopted for determining the capacities of the Channel, and to the practical operations for excavating it. It will be understood from what has gone before, that as the Trunk and its main Branches are intended to act as the receivers of supply for the distribution of water over given areas, the leading point to be attended to, is to place them in such an elevated position with reference to the areas to be irrigated, that there may be as little difficulty as possible in effecting this distribution. For this purpose in laying down the alignement, the watershed of the Country is evidently the true position for the lines of supply: & again, for ~~the purposes of~~ Regulating the ~~amount~~ quantity of water which passes through the Canal Channel, the direction must be dependant on ~~a great measure~~ facilities for escape & consequently on the topographical outline of the Country over which it is carried. In the regions connected with the Mountains it is necessary to provide for the escape of Torrents, and the heavy floods to which the hilly tracts are subjected; elsewhere it is equally desirable

desirable to obtain the aid of the natural lines of drainage in receiving waste water which it may be necessary to throw off from the Canal Channel. In both these cases, much care is requisite, as upon them depends the efficiency of the works as a machine for irrigation, and the health of the neighboring population, from free and perfect drainage. It will have been seen that the Ganges Canal in its passage through the low lands at the foot of the Sewaliks, is con-nected with extraordinary diffi-culties on the leading 19 miles of its course. On its reaching the high land of the Doab at Roorkee its general direction lies between two Rivers, the beds of which are more or less depressed below the levels upon which the Canal Channel is carried; it runs, as far as straight lines can run upon tortuous ones, upon the summit ridge from whence the water flows away to the natural lines of drainage, and consequent-ly, although the flood water on the high land may occasionally be interfered with by the regularity of alignement with which the Canal is laid out, the proximity of Rivers lying on a lower level, offers every facility for the defect being overcome by artificial means It is obvious that the same cause is favorable to regulating the Canal by the medium of Escape Chan-nels into the beds of these Rivers, and that a command is obtained over the land in the tracts border-ing upon them most especially favorable to Irrigation.

In Table F of the Appendix

I have placed the original explanation of the method adopted by me in fixing the size of the Excavated Channel; this method has not been departed from in the Project of 1850, although in details it has been much modified; the causes of these alterations have been before explained. In the Northern or Khadir tracts they depended on a change to the works connected with the Mountain Torrents, and are, therefore, strictly due to the Engineer; in the lower or Southern tracts they depended entirely on Revenue and measures for distributing the water with the greatest advantage to the Agricultural community as well as to the Interest of the State.—

By referring to the Table above alluded to, it will be observed that the design for the capacity of the Channel is founded on certain axioms by which at any given point the precise volume of water passing the Canal at this point is known. This being the case, the only questions that remained to be determined, are 1st the slope of the Canal bed, and 2nds, the depth to which the water may be carried. Both of these points are main elements in determining the capacity, but the 1st is regulated in a great degree by the necessity that exists under the climate of these provinces for preventing the growth of water weeds, and the 2nd by the desire for maintaining the depths of water, corresponding as far as possible with the average depth of excavation; what is called technically

Cummins

=nically in the Department "within Soil".-

The slopes of the bed therefore require to be dependant on the freedom of the water from vegetation, and at the same time the action of the current upon the soil. In the Ganges Canal works they have been limited to 2 feet per mile in the shingle tracts at the Canal head, and to 1 foot per mile in the Channel below them. - From the Ranipoor Superpassage which lies at a distance of 6 Miles from the head at Myapoor, the slope of the Canal bed in fact varies from 1·25 to 1 foot per mile, these slopes are carried as uniformly as possible on long lines, and they are sustained at every bridge by the bay floorings, which act as retaines for restricting the effects of retrogression. - For this purpose both the floorings and flanks of the bridges are well protected - It will be seen from what has gone before, that fall of country Exceeding the above slopes, has been disposed of by abrupt masonry descents, over which the water passes, and that at the Solani Aqueduct and its neighborhood, certain modifications of slope have been given, depending on the protective measures which have been thought necessary for that work.-

The depth of the water, or that to which high water mark is limited, was a point very prominently insisted on by the Madras Committee in the report to which I have drawn attention in an early part of this paper. - It is one more over, of which I entirely approve, and to which in fact as much

much attention as possible was
given in my original project. By
restricting the high water mark to
a limit below the Terre plein of the
country, it is evident that all the
dangers to which an embanked Chan-
-nel are open are avoided; this is a
fact which directly attaches itself
to the Engineer not only in his Esti-
-mate of cost, but of probabilities
of accident. On the other hand,
leakage and the proximity of
hollows are the invariable attend-
-ants on raised Embankments; the
first in very impervious soil may
be remedied if not altogether pre-
-vented, but the latter is inherent
in the design. Earth must be pro-
-cured either by superficial digging
i.e. by shaving from the surface a
moderate quantity of earth or by
the excavation of Tanks or Reservoirs
in both cases rain water lodges, and
during the rainy season forms
Pools and Sheets of standing water,
leading to the richest vegetation
which is maintained even after
the subsidence of the water by the
moisture derived from the Canal.
To prevent the occurence of Em-
-bankments universally, is quite
impracticable, but it may be
reduced to the lowest possible
limit, and the evil may be modi-
-fied by a judicious application
of drainage Channels, or even ~~by~~
the maintenance of Tanks, which
might be kept supplied with water,
and by constant care be prevented
from becoming receptacles for
water plants. I have endeavoured
to do this in the few cases where
Embankments have been inevi-
-table, but I have no doubt,
that

that experience will shew the value, if not the necessity, of relieving the outside of the Embankments from local inundations by cuts made into the nearest line of natural drainage; on this point there is no necessity for entering further, as it has been repeatedly referred to in former chapters. —

The Amount of water which is to be admitted into the Canal head at Hurdwar having been determined, and the detail of its distribution in the Trunk and the different Branches having been fixed: the plan that I followed in laying down the width of Channel was to assume as fixed points certain leading features, for instance it having been resolved that the discharge of water passing Roorkee should be 6750 Cubic feet per second and that certain branches should be dependant on the main Trunk for their supply, the axioms to which I have before referred, gave me the exact amount of discharge required at

The Puttiguh Branch Head
Bolundshuhur do
Koel do
Nanoon do
Escapes at the Heads of the Termini at the Ganges and Jumna. —

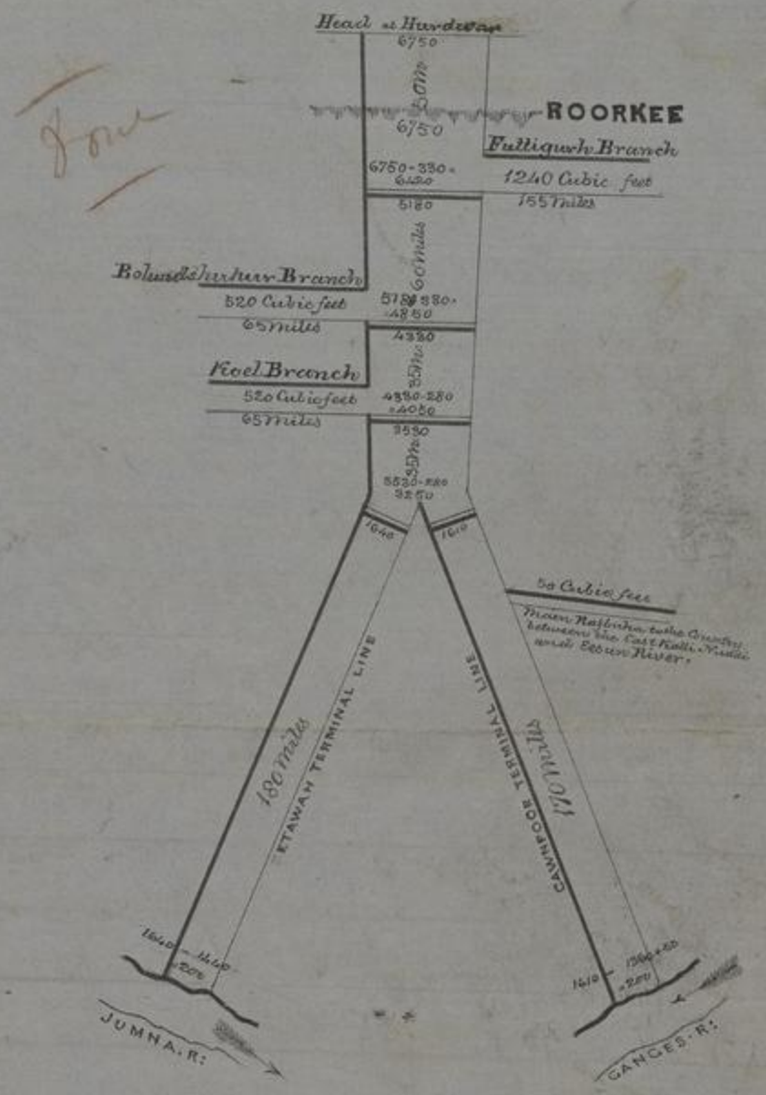
The only modification required being that, to adapt the main Trunk below the Branch heads, and ~~at that heading to~~ Escapes, to the additional volume that the Stoppage to the branch supply might ~~occasionally furnish~~. In these considerations the Skeleton which I have shewn in Diagram XVII, was designed, -

and

and it was upon this design that the Canal Channel has been excavated. To save back reference the diagram above referred to is repeated, as it takes its place very properly at the head of the following paragraphs.—

Diag: CLXIII

Project of 1850



Four

Diag 17
fig 2

The practical operations were conducted on two different plans, viz: in one of which ~~that where~~ the excavation was performed by contract, and in the other by ~~that where~~ laborers either paid by the month or day under the supervision of overseers ~~were employed~~. The first was the plan most generally adopted, although the latter has in many cases especially in the works subordinate to the main Canal in the Northern Division been very conveniently brought into requisition. The adoption of either however depended in some measure on the resources

resources of the country in which the works are situated

In the Punjab but more especially in those tracts of it lying on the frontiers of the north west Provinces, between the Sutlej and Jumna Rivers, the excavation of Tanks and watercourses has from time immemorial been a trade carried on by a class of people, nomad in habits, who attach themselves to any locality where work is plentiful, and where from the absence of restriction to grazing, their cattle can be allowed to wander about without interruption from enclosures. This class of people who under the name of "Oades" may in their habits be compared to the Gipsy class in Europe, pitch their tents on the works, selecting spots free from cultivation, and in the neighborhood of a well for drinking water. Their tents are in character like those of the Gipsy. Pieces of canvas ~~stretched~~ stretched on a pole, roofs of Sirki, a species of matting made of grass, or rough covers of thatch composed of any sort of material that is at hand, constitutes the residence of an "Oade"; here with his women, his cows, goats and donkeys, the latter being the staple of his trade; he appears to live in as much happiness and comfort as the denizen of civilized abodes, is quiet and tractable, and excepting in occasional Donkey raids on cultivated tracts, leads a life of, to all appearance, well regulated labor, interfering with no one, and in the absence of all wants beyond those of mere animal sustenance, as free and independent as the Gipsy

In

N.C.N. 545-V2-P.3-C. X.

In the very extensive excavations that have been made in the North-ern tracts of the Canal, people of this class have been collected in great numbers, and even in parts where the existence of cultivation has been greatly opposed to their natural habits, I have the author-ity from Mr Read, the Executive Officer under whom they have been chiefly employed, that their conduct is exemplary, and that the only cause of complaint, in those tracts where cultivation abounded, was in cattle trespassing, an evil which seldom or ever led to affrays, or was in itself carried to any serious extent. The people in fact appear to confine themselves to their own class, to be guided by certain munic-ipal laws, and to be ruled by Chiefs selected amongst themselves; cases of misbehaviour being taken up by a Punchayet or Committee, the decision of which is accepted as law, and never appealed from to the District courts. - A remark-able case of summary punishment inflicted on an interloper who under the character of an "oade gained admission into a Camp and married one of the oade women may be introduced here in exemplification of simple and unsophisticated justice; it will illustrate the character of these tribes and shew the class of people with whom we were brought in con-nection. - An Athletic, fine looking man, bearing in outward appearance the character of one who had been used to excavating and in every way like one of this class of people, joined the works

and

and attached himself to an oade Encampment. A love affair in which one of the oade ladies of the family was implicated, led to a maniage between the lady and the man who is the subject of the present Story. The parties remained for some time in the Encampment when it was discovered that both had absconded, the man in question having by some means or other proved that he was not an oade. The discovery was not made for some days after the elopment, and the parties must have proceeded to a considerable distance before any steps were taken: No detective police in Europe could have acted with more judgment secrecy and quickness than did a chosen party of the Tribe who were immediately put upon the trail. Both man and woman were brought back, tried with all due form, and judgment executed on the spot. The award was by no means a bad one either for treacherous ~~husbands~~ males or for false ~~wives~~ females. Oade Law pointed both gentleman and Lady in party colors of red black and white, seated them on two separate donkeys with their faces turned towards the animals' tails, promenaded them through the different oade encampments, and finally ejected them with ignominy from the precincts of the works. The whole of this proceeding was conducted with perfect gravity, and doubtless to the extreme satisfaction and approval of the collected Tribes. This is one out of many instances of proof of an existing internal economy amongst this people, and

their

their independence of action even
under the eye of the British police.
The Oade is remarkable for the
large size of the Phoura which he
uses, it is frequently inlaid and
ornamented, and is quite pecu-
-liar to this class of People. The
use of the donkey for carrying earth
is almost entirely confined to the
Oade, who does not appear to use
either Men, women or children
for this purpose. He is improvi-
-dent, and appears to be satisfied
with a mere subsistence; time is
to him a matter of indifference,
with the nomad habits that he pos-
-sesses, it is wonderful to see how
he will procrastinate his departure
from the ground of an Encampr-
-ment if he sees the slightest prob-
-ability of obtaining work even
at a distant period in its vicinity
For months did Oade encampments
hang about the neighborhood of
the Futtiguhr Branch head under
the hopes of the Channel being
commenced upon, and I believe
that whatever difficulty there may
be in collecting the parties on
the commencement of a new work,
there is an equal disinclination
on the Oades part to leaving when
it is completed. This, however,
is confined entirely to the Northern
tracts upon which the Canals in
these Provinces have been undertа-
-ken. In the Southern Divisions
of the Ganges Canal works, the
name of the Tribe as Contractors
is unknown; The Oade loveth
not the regions of Towns and
Cities or the proximity of agricul-
-tural industry; his fields are those
where

where his Goats and donkeys can
feed unmolested, where he can
enjoy fresh air and drink pure
water. The tribes appear to depend
in their accounts on a man selected
from the "Lalla" or Bunnia Class,
who makes them small advances,
and arranges the distribution on
settling day: this appears to be
universally the case when the
Oades are working in large parties,
but when detached, or carrying on
works in small bodies, the Cash
settlements are made without the
intervention of any middle man;-
the Contractor placing implicit
belief in the measurement made
by the European Officer, whose
decision in all cases is looked upon
as a point not to be disputed.-
With this simple class of people
no written contract is entered into,
and I am not aware of its ever
having been abused; atleast three
quarters of the Eastern Jumna Canal
was excavated under my own
superintendence by Contractors of
this class, by far the greater portion
of the leading 110 Miles of the
Ganges Canal works, was done by
the same people, many of them
Children of those who had done
so much work for me on the
Eastern Jumna, and I can speak
freely of their habits as orderly and
quiet to a degree that could hardly
be understood, by those who have
resided in the neighborhood of
or have in any way been connected
with European Excavators.-

Besides the Oades, there
are numerous other classes of
Excavators, whose occupation,
however

however does not appear to be con-
-fined to digging; in such a large
body of works each and all of
these classes are represented, with
more or less benefit to progress.—
Reference will be made to them
in the detail of excavation.—

Daily and Monthly Laborers
have been chiefly confined to de-
-tached works in the Northern Division,
to excavations for Masonry works, and
in the Cawnpoor District to parts
of the Canal Channel.— In making
use of this Species of labor, however
task work is demanded, that is
to say, each man or each party
of men are bound to do a given
quantity of work, a failure in
which leads to a reduction of pay.
An able bodied man is supposed
to execute 83·33 Cubic feet per day.
Cooli or carriage labor ~~is~~ is de-
-pendent on the locality, and the
distance to which the earth has
to be removed, I shall enter on
this subject more fully presently.—
As a rule there can be no doubt
that Earthwork especially that
in Embankments is better done
by daily Labor than by Contractors
The former is dearer in its original
cost, but where embankments of
made earth are concerned, it is
I believe in the end cheaper.—

With these preparatory remarks
I shall enter upon a description
of the Canal Excavation, separating
it into Sections or lengths, due to
the quality of the Soil with which
we have had to contend.— Under
this consideration the Sections which
I have enumerated elsewhere, ap-
-pear to be the natural divisions
into which the description falls.—

Three

Three great Divisions consisting of Shingle to the north, Sand in the centre, and clay in the lower regions offer in abstract a State=ment of the nature of our Excavations: These with modifica=tions due to local causes give us the following.—

Section I. From the Head to Roorkee

A. Supply Channel from the Ganges to Myapoor.—

B. From Myapoor to the Puttri Superpassage.—

C. From the Puttri Superpassage to the Rutmoo River

D. From the Rutmoo River to the Assofnuggur Falls.—

A. Supply Channel from the Ganges to Myapoor

This Excavation consists of a Channel excavated through the bed or branch of the Ganges, from a point above the Town of Hurdwar to the Dam and Regulating Bridge at myapoor; it includes also very heavy Excavation in the neighbor=hood of the Myapoor Works, and on the down Stream side of the Dam:- the construction of bunds, besides a quantity of Shingle work subordinate to the purpose of taking the water from the main Ganges. This excavation is entirely in heavy shingle, or boulders, many of them of large size, and the whole very compactly embedded; the work is difficult and expensive and very destructive to tools. The length of Excavated channel from the Ganges

Ganges to the Myapoor Regulator is 14750 feet; its width 300, and its average depth 7½ feet.- The slope of bed is equal to 8·59 feet per mile

Hall

From the Dam on its down stream side, a cut of similar proportions and slope of bed to that above described, also excavated in shingle has ~~also~~ been completed, this, ~~with~~ and the extensive clearances in the neighborhood of the works including the excavations of the Regulating Bridge, ~~were~~ were done partly by contractors and partly by daily people; the rates vary considerably depending on the position and depth but they average on the whole Rs 4..5..1 per 1000 Cubic Feet.- The maximum being Rs 6..6..1 and the minimum Rs 2.. 5.. 10, when daily labor was used.- The rates to contractors per 1000 cubic were Rs 6/- & Rs 1/8/0 respectively I may observe that between the side of the High bank, on which the Gunes Ghat was formerly situated and the Regulating Bridge the distance is 350 feet; the Excavation on this line was through an upper soil of a very tenacious clay, with sub strata of boulders, the total depth being 21 feet.-

B. From Myapoor to the Puttri Surpassage

The Excavation on this line was the first that was undertaken on the Ganges Canal works; it was commenced on the 16th April 1842 on which day the first ground was broken.. The work was taken up by contractors of a variety of descriptions, the greater number of the

the Class which I have above mentioned under the name of Cadres, it was distributed in lengths of 25 feet, and the rates were fixed at

From Surface to 5 feet in depth @ Rs 2.0.0 per 1000 cubic feet
" 5 feet to Bottom — " 2.8.0 per — "
Boulder or Gravel at any depths " 3.0.0 per — "

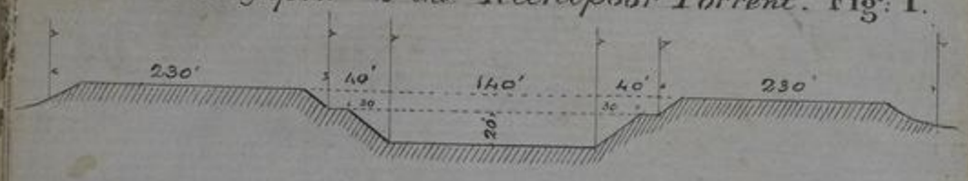
***

with the exception of the track immediately in connection with the Ranipoor Torrent which was Sand, the line from the Myapoor Regulator consisted of a Subsoil of a good firm clay, uninterruptedly to the neighborhood of the Ranipoor Torrent; from whence to the Puttri it became more mixed with Sand, with occasional traces of Shingle shewn in detached pebbles. The Substrata throughout were Sandy, although for the two leading Miles of its course, as far down as the Site of the Bridge at Kunkhul the Excavation on the lower 5 feet was through heavy Shingle.

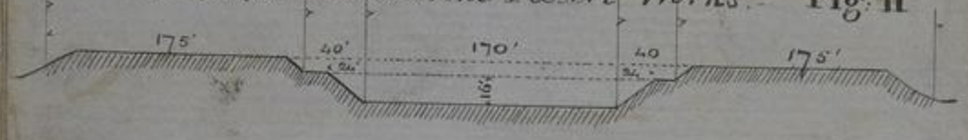
On this digging of which the Sections were as follows:

Diag: CLXIV

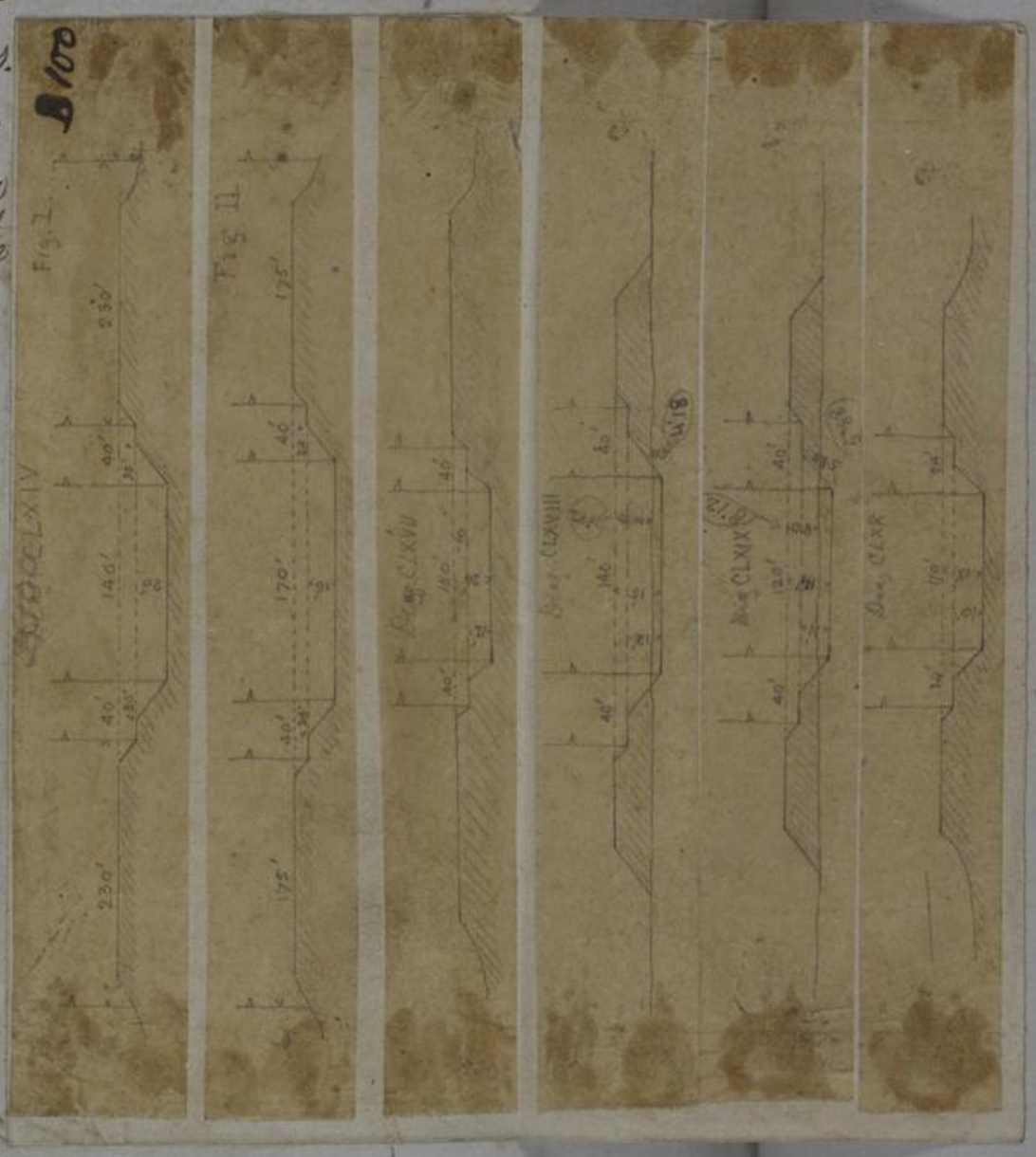
From Myapoor to the Ranipoor Torrent. Fig: 1.



From the Ranipoor Torrent to the Puttri Works. Fig: II



no Spring water was met with, the average depths on Figure I may be estimated at 18·6 feet
and the Maximum at 25·08 feet
Minimum 4·8 "
On Figure II the average depth was 16·5 feet
Maximum 24·75 feet
Minimum 10·73 " The

*** The excavation was commenced under my direct orders by Mr. Thomas Wright an Assist Executive officer who died in 1846 after doing much good service. Capt Richard Strachey of the Engineers however who was appointed to the Executive charge of the works in the Northern Division has the merit of the organization of the Establishments & of placing the works on a prosperous & I consider that much of the method & order which ultimately prevailed is due to the independent character of the Officer and well known talent of that Officer

The rates per 1000 Cubic Feet will be understood from the following Table.

	Rs.	as	Pie
From Myaporr to Ranipoor. per 1000 Cubic Feet - average on whole	2	14	2
From Ranipoor to Puttri - per 1000 Cubic Feet. average on whole	2	"	10

C. From the Puttri Superpassage to the Rutmoo Rives

This is perhaps the most interesting line of work that has been excavated; it embraces the whole of the digging which as I have explained in the early part of this paper, depend-ed on the retrospositum of the Falls, so as to enable the Puttri torrent to be passed over instead of through the Canal Channel; the length is equal to 16810 feet.. On its course it passes through a ridge upon which the villages of Gurh and Saynibas are situated, and with the exception of the subsoil to a depth of from 7 to 20 feet, it is entirely excavated through Earth impregnated with Springs.-

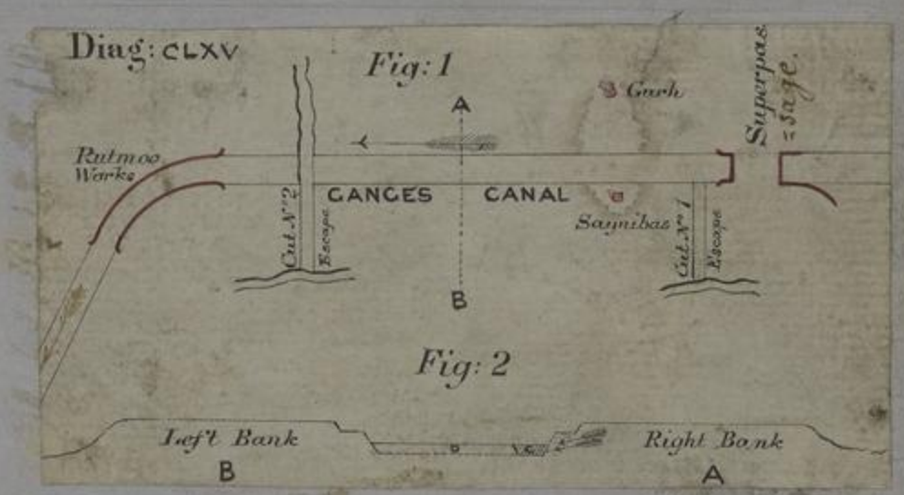
I have in the 1st. Chapter under the head of Superpassages described the arrangements that were made at the Puttri Superpassage for enabling the masons to work on the lower levels, lying 17 to 21 feet below the surface of the Spring water; the plan that was adopted there, was pursued on the line of excavation which I am now describing, the work was tedious and very expensive, it required, moreover, the constant vigilance of an active supervisor, to see that what was done in one day, was not by the action of the Springs undone the next. The nature of the country through

through which this digging was
executed was that of the Durai,
before explained, the Spring water
which in the "Bhabur" belt is kept
down by impervious superstrata,
rises immediately it Escapes from
its bondage. At the Baushahpoor
Nulla which is situated within
600 feet of the Rutmoo, and which
is intersected by the Canal, water
runs in a perennial stream, The
difficulties of excavating this por-
-tion of the Canal may be com-
-prehended by referring to the stream
in question, which naturally runs
on a level of 8·18 feet above that of
the Canal bed. This Nulla was
merely an external exhibition of
the Spring level throughout the
whole line of Country to which
I am now referring.

In the Excavation for the
Puttri Superpassage works, it will
be recollected that advantage was
taken of the fall of Country at right
angles to the Canal alignement,
to carry a ditch from the Canal in
the direction of the Slope, so as to
give an Escape to the water as
it collected in the Excavations; the
effects of this Escape were in the
highest degree satisfactory; under
Careless Superintendence, it would
have been useless; with the Ener-
-getic Supervision that it fortu-
-nately had, it was maintained
in an open State throughout the
progress of the work. It was this
persevering management, that
enabled Mr Login the Officer, under
whom the work was executed, to
make any progress at all, the de-
-termined opposition of the Springs
acting in Sand and Mud, could
only be overcome by the most minute
vigilance

vigilance, and by the constant application of remedies.

After removing the subsoil or that unconnected with Springs an Escape similar to that which was executed near the Puttri works, was made near the Baushah poor Nulla. The distance from the Puttri to this Nulla is 10804 feet, so that in making use of the Baushah = poor Escape for the relief of Spring water during the Excavations, a considerable slope was available The direction of the Spring current was from North to South, or from the high to the low land, the Canal Channel intersected this at right angles; Mr Logins plan of operations will be best understood by diagrams shewing the line in plan and section.-



The true section of the Canal in its full depth is represented by the dots; the way that this was reached will be understood by the shade C which represents a ditch or cunette, in this case a catch drain for the Spring water which flowed in the direction of the arrows This Cunette was carried along the whole line of excavation and ter- -minated in the Escape No 2: both

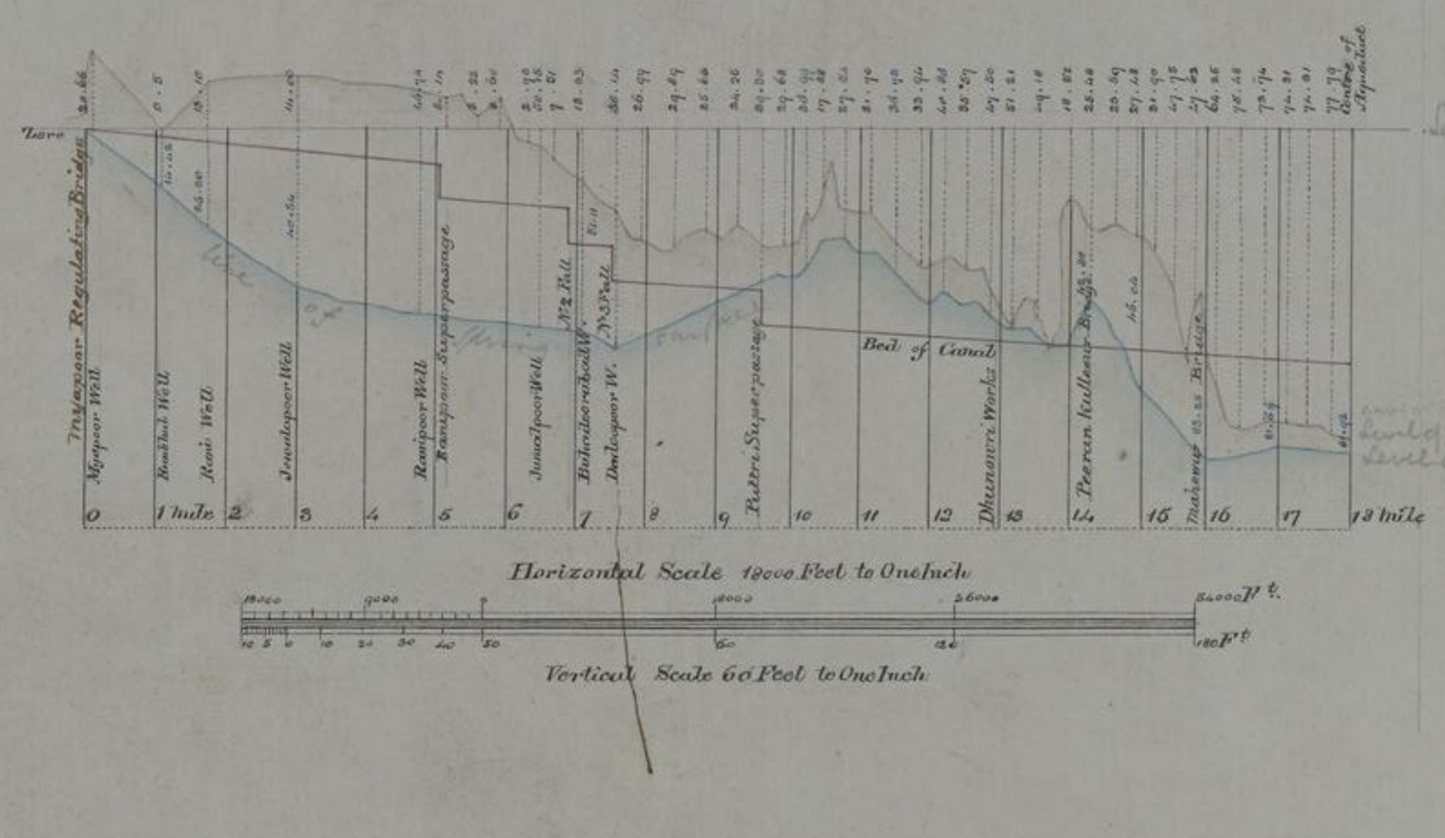
Cunette

cunette and Escape were main=
=tained in a constant State of ef=
=ficiency as regards the free run
of water. By the interposition of
the Cunette C, that portion of the
canal Channel at D was excava=
=ted without trouble, as it was
entirely cut off from its Spring
supply: the process was a very
gradual one, as the depth of the
Cunette was increased so did the
portion D become relieved of its
difficulties; it was an operation
requiring especial care, and in a
Pecuniary point of view the
greatest attention to prevent the
~~work~~ of one day being obliterated
by the action of Springs during
the night time. The whole was
completed, however, and I consider
it to have been one of the most
satisfactory works on the Canal.

The Section of the Northern
Division figured on the opposite
page shews the levels of the Springs,
on the whole line from Myapore
downwards, to this I would especi=
=ally draw the readers attention;
I may observe however that be=
=tween the Puttii and the Rutmow
their maximum depth below the
surface of the Country was only
7½ to 20 feet whereas the depth of Chan=
=nel to be excavated was equal
to 27 feet. The greatest depth of
digging at the Gunbridge was
42 feet, but this extended for a
short distance only. The soil is
more or less Sandy although mixed
with clay which judging from
the excavations and the block
sinking at the Puttii works, lies
in narrow irregular strata, with=
=out

Diag: CLXVI

Section of Northern Division, showing Depth of Spring Water



Horizontal Scale 12000 Feet to One Inch

Vertical Scale 60 Feet to One Inch

=out any continuity. —

The work was done partly by Monthly paid Laborers, and partly by contractors on rates as specified below. —

Alder

Average	2..14..0	per 1000 Cubfeet
Maximum	4.. 2..0	do
Minimum	1..14.. 0	do

D. — From the Rutmoo River to Roorkee, or to the High Land of the Doab. —

The Valley of the Rut=moo which is about One mile in breadth rests its right boundary on the Peeran Kulleem Ridge. This ridge which is 2 Miles in width comes in contact on its Southern boundary with the left of the Solani Valley over which the great Aqueduct is constructed. The Aque=duct delivers the Canal Channel on Roorkee, at which point having entered on the high land of the Country, it may be considered to have passed its difficulties.

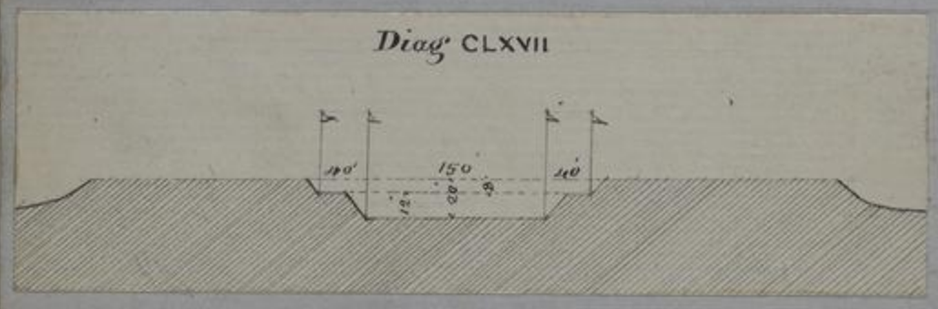
As the description of the whole of the Solani Aqueductworks including the Embankments, the Earth for making which has been procured in a great measure from the Peeran Kulleem ridge, is en=tered in a separate Chapter; the subject of the present Section relates merely to the Embankments lying in the Rutmoo Valley be=tween the Peeran Kulleem ridge and the right flank of the Dam on that River, with general re=marks on the ridge digging. The Embankments here alluded to were partly made from Earth taken from the outside in trenches

dug

dug to a depth of 2 feet, and partly although in a much greater de=gree from the ridge; the former being done by contractors, and the latter by Monthly paid Laborers, who were employed on Wagons run=ning on Tram roads or rails, in carrying the soil excavated from the high land to the lower levels on which the Embankments were formed.—

The Section of the Canal on these Embankments is as follows:—

Diag. CLXVII



the right Embankment being made of additional height and width, and both of them on their approach to the Peeran Kulleem ridge having been laid out on extended dimen=sions.—

The depths of Channel dig=ging, to gain the true Canal levels, did not exceed 6 feet, the banks therefore, have been a very important part of the undertaking; they have been well consolidated, however, and their proportions are on a large scale.—

The average cost per 1000 Cubic feet was

Maximum Rs 4.. 3. 8
Minimum Rs 1 - 10. 6

Although the rates of Ex=cavation in the Peeran Kulleem ridge will be explained in detail when describing the Aqueduct works, I may mention here that the depth of digging in its maximum dimensions was equal to 37 feet.

the

the cutting in fact through this ridge with the exception of a hol-low near its Southern limit & averaged in depth 31 feet. The soil consisted of parallel strata of Sands and clays, perfectly hori-zontal and corresponding with those on the Roorkee side of the Solani valley; there were clear traces of a superficial deposit probably of great antiquity, over-lying an ancient surface (marked) occasionally by depressions, in all probability those of drainage. This cutting was most remarkable for a Stratum of blue clay 3 feet in thickness like that which is commonly found in Old Tanks and Reservoirs, connected with one of a reddish Sand, replete with traces of carbonaceous matter exhibiting themselves in form and appearance not unlike those connected with the Lignite deposits so commonly found in the Sewaliks. Although a portion of the Excavation, especially that near the village of Peeran Kulleem was done by Excavators on Contract by far the greatest proportion of the Earth was carried either to the Rutmoo or to the Solani Embank-ments by Railway. The cost per 1000 Cubic feet in the first case may be estimated at Rs. 3-0-5 That on the Railway work runs through variations depending entirely on the distance to which the Earth was carried, the average on a great number of rates, giving a cost of Rs 3..11..4 per 1000 Cubic feet of excavation

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Section II. From Roorkee to the Nanoor Regulators

A. From the Aqueduct at Roorkee to the 110½ Mile

B. From the 110th to the 180th Mile

A. This line of digging passing through the Saharunpoor, Muzuffur-nuggur and Meerut Districts, was commenced in 1842 simultaneously or nearly so with that in the Khadir. The works were organized under the management of Captn Turnbull of the Engineers, and the Canal Channel was begun and completed almost entirely by the Coolie class of Excavators. In 1847 Captain Turnbull was relieved from his duties by Lieut Edward Fraser of the Engineers who resigned his charge to Mr Frederick Read in the Month of October 1830.

The rate allowed to the Contractors ~~varied~~ in the first instance from 2 to 2½ Rs ₱1000 Cu. Ft: this gradually settled down to a fixed standard on which the work was carried to completion; under this standard the rate allowed for a Canal, the rectangular width of which was 130 feet, and depth 10 feet with slopes 1½ to 1 was equal to Rs 1.. 14.. 0 per 1000 Cubic feet; - to depths below 10 feet, the rates were fixed at Rs 2.. 6.. 0 per 1000 Cubic Feet. The earth in all cases had to be carried on an average to a distance of 150 feet. -

The system on which the contract work was performed was simple.. The Contractors each of whom had a portion of from 50 to 100 feet in length of the Channel allotted

allotted to him) gave their work out to their laborers or sub contractors at Rs 1..8..0 in the first case above mentioned, and at Rs 1..12..0 or Rs 2..0..0 per 1000 cubic feet in the second.- They (the Contractors) finding the tools (Phoonas and baskets) for the laborers.-

Three able bodied men will excavate and carry out 250 cubic feet per diem, and earn 6 annas or 7 annas each, when the digging is not more than 10 feet in depth.-

The whole of the levelling and smoothing off of the Embank-ments, together with the finishing of Slopes, is included in the above mentioned contract.-

There are numerous curves on this line, the leading one of which commences at the down-stream Terminus of the Solani aqueduct; this curve is described on a radius of 6617 feet; it is ne-cessarily abrupt from the circum-stance of the relative position of the Aqueduct to the direct line of excavated Channel, to both of which it forms tangents, its concave or right side has been protected by a masonry Revetment. The Liburkeir Curve is a gradual one on a radius of 57456 feet; those from Baira to Davli are on radii of 5730 feet; that at Sulawun 4 miles ~~feet~~: and the great curve to the South which brings the Canal to bear upon the Country lying between the Kanoon and the Eastkalli nuddy Rivers may be described as a Polygon with the corners cut off, by Curves on radii of from 3 to 5 miles in length.

The Supersoil throughout the

* The actual rates at which this portion of the Canal channel was excavated were as follows.

From the Roorkee Aqueduct to the 50th mile, the rectangular channel being 140 feet in width, the rates were 2 As. ₹ 1000 C feet to a depth of 10 feet from the surface below which the rate was raised to 2 As 8 annas.

From the 50th to the 84th mile inclusive, the rectangular channel being 130 feet in width, the rates were 1/14 and 2/6 as under the same restrictions with regard to depth.

From the 84th to the 105th mile inclusive, the rectangular channel being 120 ft in width the rates were 1/8 as ₹ 1000 C ft.

From the 105th to the 110th mile inclusive the rectangular channel being 110 ft in width the rates were 1/8 as ₹ 1000 C feet.

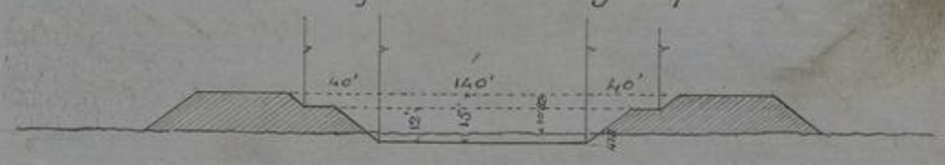
the whole of the country from Roorkee to the 110th mile consists of clay overlying sand, the depth of this superstratum of clay varies from 10 to 14 feet. On the whole tract the surface of the country is marked by sand ridges, which appear most prominently between Roorkee and Muzuffurnuggur, as well as on the line from Baira to Khutowli. These sand ridges appear again in great force in the neighborhood of Sirdhurna. No Spring water was met with in excavating the Canal channel, although the foundations of masonry works came in contact with it at all the works from Sulawur downwards. As a ~~determination~~ characteristic feature the whole of this line through which Excavation was carried may be considered as sandy. A great portion of it was land used either for Khureef or rain crops only, or for cold weather crops sown in dependence on the rain that falls during the months of November, December and January. It is remarkable for its dryness, Spring water being found at great depths The Excavation on the whole line may be considered easy, and progress was carried on without any interruption.

There are 2 points on this line where the levels of the Canal bed, were so little depressed below the Surface of the country that it has been necessary to raise Embankments to complete the Canal Channel; the value of these works may be estimated by the following Diagrams.

Diagrams

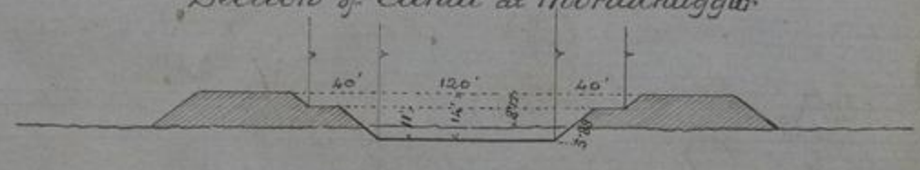
Diag: CLXVIII

Section of Canal at Toghulpoor



Diag: CLXIX

Section of Canal at Moradnuggur



The shaded portion representing the artificial work, which is made of Earth well rammed and watered, built in layers of 2 feet in thickness These Embankments are situated at Toghulpoor, and at Moradnuggur, in the former case the length is equal to 4900 feet, in the latter to 7100 feet ; the earth required has been collected from superficial excavations in the neighborhood, excepting in extraordinary cases where as at the Toghulpoor and Moradnuggur Bridges, a deficit in Material has been made up by digging Circular Tanks centrically situated on the right angles formed by the Bridge ramps and the Canal Embankments. As the greatest care has been given in the construction of these works, I do not consider that they will lead to disappointment. I am not quite satisfied with the out-side hollows from which the Earth has been taken; they have now however existed for some years without giving annoyance, and it is, therefore, possible that from the absorbent nature of the soil the water that would otherwise collect is rapidly sucked up. I have in no case allowed inlet to be carried into the Canal Channel for reasons which have been fully explained before; should difficulties

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Part III

=ficulties, therefore, exist hereafter drainage cuts in the way which has been laid down for guidance must be excavated so as to connect these hollows with the low land lying near the beds of the Rivers on the right and left. The Raj=buha System which entails such a reticulation of watercourses over the surface of the country will so completely change and modify the natural water shed, that until its effects are shewn, it appears to me to be unwise to lay out drainage cuts, excepting such as are indispensably necessary for present purposes.—

The Excavation of the Three Escape channels at Khutowli, Mahomed Aboo's Nulla, and Jamni Khoord, was carried out in the same way as that of the Main Trunk; from its reduced size the rates were reduced to Rs 1. 8. 0 per 1000 Cubic feet

The rates of digging, including contingencies of Forts, may be understood from the following Table taken from the Bills submitted by the different Executive Officers who have held charge of these works

By whom Executed	In what Locality	Rate per 1000 cubic feet		
Lieut A. D. Turnbull	From 24th to 50th Mile	2	4	3
" E. Fraser	do	2	"	11·9
" do	do	2	1	2·5
" do	" 50 to 110th Mile	1	15	10·1
Mr Read	" do	1	15	0·6
do	do	1	15	"
do	" 24th to 50th Mile	2	"	11
do	" 50th to 110th do	2	"	4·2

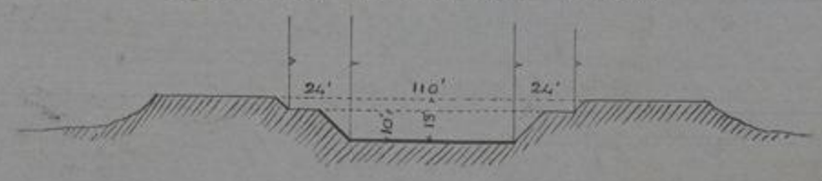
B. From the 110th to the 180th Mile or to the Narown Regulators.

The Excavation here was done under the management of Mr

Mr Philip Polk, the dimensions of the Canal in their extremes are shewn in the following Diagrams.

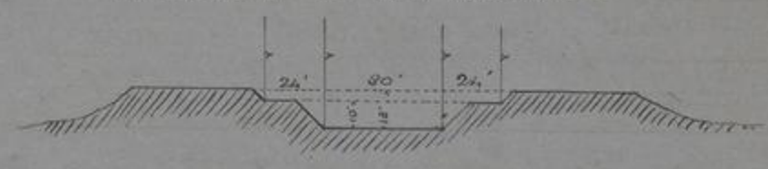
Diag CLXX.

Section at the 110th Mile



Diag: CLXXI

Section at the 180th Mile



Shahee

The work is carried through the Meerut, Bolundshuhur, and Alliguh Districts. The Soil is of a better description than that of the Sahaunpoor and Muzuffurnuggur Districts above described, it consists of a good earth, although sand shews itself more or less at depths even with the Canal bed. The country is generally speaking highly cultivated, although in the neighbourhood of Khoorja where we again come in contact with sand ridges and in comparatively low ground in portions of the Alliguh Distuct, cultivation is less abundant. Springs were not met with in the Excavation of the Canal Channel, although in the block foundations at the Simna Falls, we come in contact with them at a depth of 9½ feet below the level of the Canal bed. As a general rule the soil is better here than it was in the line from Roorkee to the 110th Mile.

The highly cultivated State of the country acted as a bar to the trade contractors taking up work

work under Mr Volk; they carried on progress up to the head of his Division in prosecution of the work which they had began under Mr Read, but they refused to commence a new series under the difficulties offered by cultivation to the maintenance of their Cattle. The early part of Mr Volk's operations, therefore, were prosecuted under many interruptions, but of a nature so similar to those that I met with in establishing the works in 1842 at Rinkhut, that I cannot do better than describe them in Mr Volk's own words.-

"At the beginning of the excavation of the 3rd Division (that is, that of which I am now writing) considerable difficulties were experienced in procuring Contractors and Laborers, although previous to the commencement of the works many parties had forwarded applications for contracts. The cause of this keeping back was said, to be dissatisfaction with the rates, and the hope that by delaying, more favorable terms would be offered. Several parties that had already commenced work left the Canal, declaring that they could not continue to work at a loss.-

"Several Months passed away, during which time I commenced working with small parties of daily Laborers, which measure had the beneficial effect of convincing the contractors that their intriguing would not prevail on me to raise the rates. Finally work commenced under contracts

"The

"The rates for excavating 1000 Cubic feet vary from Rs 1.8.0 to 2 Rupees, according to the nature of the Soil, the depth of Canal, and the distance to which the earth is to be carried. For this sum the Contractor engages to dress the slopes, towing Path and banks, to make all the required daghels (linings out) to excavate the bound=ary ditch, to make a road along the Canal as far as his contract extends, and to keep the same in repair until his accounts are closed and settled.

"No advances of money were given; monthly once or twice pay=ments were made for the work executed, keeping 1/5th to 1/8th in arears as a Security for the faith=ful execution of the agreement on the part of the Contractor

"The Contractor had to fur=nish his own Tools, keeping them in repair at his own expense".

The Men who were thus employed on Contract work, were of all denominations, many of them taking up long lines, the maximum extent of any single Contract was equal to 3 Miles, the minimum to 100 feet. The work has been very neatly executed, although there appears to have been more trouble with Contractors of the Sort engaged on this line, than there was with the Odde Excavators In all cases of contract, moreover, written papers were signed and sealed before the work was begun and upon the letter of these agree=ments the work was executed.

Throughout

Throughout this line the berm or towing path has been formed on one level with reference to the Canal bed. Where the natural surface was too high, the superfluous soil was removed; where too low, soil was added to it. The whole section is on one uniform design, without the irregularities that have been described as existing in the tracts below Roorkee, and as far as the 110th mile, where the nature of the soil and the extreme depths to which the excavations were necessarily carried, were opposed to a perfect uniformity of berm levels.

From the 176 to the 179th mile a good deal of Embanking has taken place, the necessity of which will be understood by a reference to the longitudinal Section of the Channel: The earth required for these Embankments has been procured by Excavating Tanks or reservoirs on the outside of the Canal boundaries, to an extent equal to the Cubic Content of material required, the depth of each tank being limited to the rates of Superficial digging. It has been an object here to make these Tanks as deep as possible without proceeding beyond that due to the above rate; the depths, therefore, do not exceed 10 feet, which it is supposed will be sufficient (if the Tanks are kept filled) to prevent the growth of water plants. It is proposed also that their preservation free from reeds and vegetation should be

be considered a part of the con=
=servative duties of the Division;
that means shall be taken for
keeping them filled with water
from the Rajbuha Heads; and that
they shall act as supplies for
Machinery irrigation to the lands
lying on their borders. There was
a choice between two, Evils, either
by taking a superficial soil from
the country, by which the carriage
of material to the banks would
have been enormously expensive,
and a very extensive depression of
surface would have been caused
over large areas leading to probable
inundation during the rainy months
or, by Excavating deep reservoirs,
which whilst they afforded material
for the required purposes of Em=
=bankments, acted as recipients for
the rain water, which in the former
case would have been scattered over
the surface in the form of inundation
The position of the Canal with
reference to the beds of its boundary
Rivers is such, that there can be no
difficulty in getting rid of inun=
=dation.

The rates per 1000 Cubic feet
for Excavation including contingencies
are shewn in the following Table

Main Canal	1	12	3	per 1000 Cubic Feet
Escape Channels	1	5	"	do

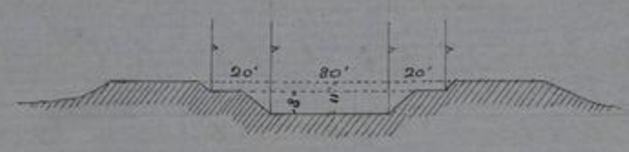
Section III. Cawnpoor Terminal Line

The Excavation
of this Canal was commenced in
the Cold weather of 1849/50, the
leading

leading hundred Miles under the management of Lieut Dodgson and the last 65 under that of Lieut C. W. Hutchinson of the Engineers; the work was completed by the former Officer. The dimensions of the Channelson its extremes are shewn in the following diagrams

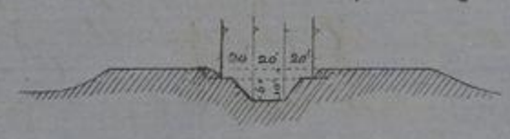
Diag: CLXXII

Section at the Head or 1st Mile



Diag: CLXXIII

Section at the Dukhapoor Bridge



The State of the Country through which this line is carried is generally speaking well cultivated, it is richly so at many parts especially in the Cawnpoor District, elsewhere it is traversed by extensive Plains, but where these are absent, the Cultivation is of a high order. The existence of these Plains is dependent in a great measure on the presence of Reh, or Soda, with which the Soil is impregnated. the Surface is hard and intractable at these Points, although the Subsoil is worked without much difficulty. Kunkur presents itself in great quantities throughout the whole of this region, it appears to me to be almost universal; where it is not found in block, it is found in gravel, and as the whole of it is highly calcareous, its presence is a great resource in Masonry building. The presence of Reh, is very detrimental to earth required for brick

brick making, although in other respects time only can shew in how far it will effect the value of the Canal as a Channel for distributing water to the Irrigators. From the observations of the few years that have elapsed since the Excavation was began, I should conclude that the soil throughout is of a very retentive nature, and that in this respect it will be favorable to economizing the supply.

There appears to have been greater difficulties here even than in the Bolumashuhun District in getting Contractors, and in many cases in collecting workpeople at all; the former arose undoubtedly from our having arrived at a still greater distance from the tracts presented by these people, the latter from the same causes as have been described before, viz^{t}: the desire to force us into an increase of rates Lieutt Hodgson who had the control of that portion of the Line passing through the Alliguhan and Mynpoory Districts, commenced operations by establishing two classes of Excavation, viz^{t}, one confined to that of the rectangular section, and the other for removal of the slopes, for this he determined averages of Rs 1..14..0 and Rs 1..10..0 per 1000 Cubic Feet; the first on the early part of the line where the width of the rectangular section varied from 80 to 64½ feet in width the latter on its decrease to a width of 40 feet. It was upon these rates that my Estimate of 1830 ~~was~~ was framed. Circumstances however, which

which can be best explained in the words of Lieut Hodgson's own report necessitated an increase, and there can be no doubt that such was ~~necessary~~ justifiable. - Lt Hodgson observed "The rate of Rs 1..10..0 per 1000 Cubic feet of Excavation was fixed by me under the belief that Contractors to whom I had given out work were carrying it on without difficulty at the rates of Rs 1..3.0 to Rs 1..4..0 per 1000 Cubic feet for the mere excavation of the rectangular Section of the Channel, exclusive of Slopes and the final formation of banks, for which I calculated that only a small addition to the rate would suffice I have, however, since then found out that for a distance of 12 miles throughout which I had broken ground, the Contractors have been praying their laborers at the rate of Rs 1..8..0 and Rs 1..9..0 for the mere excavation of the Centrical part of the Section, and throwing the earth into irregular banks.-

"The work being only carried on by means of advances to the Contractors (on which plan alone did I find it possible to obtain them) it was not for some time that I discovered that this had been the case, nor indeed until very lately did I make myself certain of the extent to which it had been carried, and since the discovery I regret to say that work has almost stopped, owing to the laborers refusing to work at rates very materially lower; indeed whilst working at the high rates

rates I have mentioned, I was con-
=tinually met by complaints from
them of the small remuneration
their labor obtained - However,
that a rate lower than those will
be accepted by them after the lapse
of a little time I have no doubt,
from the experience in the other
parts of the workings; yet it is
perfectly clear that a higher
rate must be allowed than
formerly supposed, and this
more especially in all the shal-
=low diggings and Oosun, (Reh
or Sooa) soil, which in the advanced
part of the line not yet opened
upon, prevail to a very great extent
Willshire
That in some parts of the
last 80 miles of the digging, the
rate, of the finishing work will not exceed Rs 1.. 10.. 0
per 1000 Cubic feet I hope; but that
that will be the lowest seems clear
for I am now in several places
completing portions including
the formation of Banks, and the
extra payments for the latter work
and also for cutting the slopes
and making the boundary ditches
have brought the cost up to Rs
1.. 8.. 0 per 1000 Cubic feet - To this
will have to be added a small
amount for planting grass on
the slopes and also a percentage
for expense of Establishment, which
will leave almost nothing to
provide for keeping in good order
the slopes and banks previous
to the completion of the several
Miles or portions for which Bills
will be submitted - I must also
add that on no part of the works
are either the Contractors or Laborers
satisfied; of the former I am per-
=fectly aware that the profits

have

have been nothing scarcely, and the latter do not on an average make anything approaching to the usual daily payment of six pence that prevails in the Department of Public works.- My experience from actual ex-=cavation of the work as yet extends as far as the 56th mile to a width at bottom of 57 feet, so that I can only judge of the probable cost of the lower part of the division very imperfectly: but it is clear, that as far as we have yet gone, the rate per 1000 Cubic feet has not decreased but on the contrary increased with the diminution of channel This can only be accounted for on the supposition that the class of Labores required, are more abundant at the head of the Division than in the lower parts At the same time I find that the proportion of carriers to dig-=gers amongst the Squads of workmen does not differ in parts 80 feet and 60 feet wide, and it is clear that a very trifling if any decrease in the rate can be made for decrease of width of Channel; whilst the cutting away of slopes, the formation of banks, and the contingent expenses remain the same for both sections, and consequently bear a much greater proportion to the plain digging in the narrow than in the wide section thereby causing rather an in-=crease than a decrease to the rate as the Canal narrows.—

"The

"The cheapest parts of the digging are the deepest and such are the parts in which I have stated that I am completing work for Rs 1..8..0 per 1000 Cubic feet; the reasons of the lower cost in such parts are obvious, they being always in cultivated lands, and the harder surface soil and the Stratum of Kunkur (invariably to be cut through) bearing a much smaller proportion to the softer under soil (generally in such situations partly sand) than in shallower places.-

"The 12 miles I have before alluded to are from the 46th to the 58th, throughout either not exceeding 5 feet in depth consisting of loose soil mixed intimately with small Kunkur and Bujri all unfit for use from its impregnation with Soda- There are also parts where the Kunkur formation is partially consolidated which is very hard to dig through. The latter parts are of course exceptional cases, and the high rates there will admit of explanation. At present no one will dig in them. -

"To state then the rates which appear to me now likely to cover the expenditure;

"From the Head of the Division to the 60th Mile on the whole number of Miles, and exclusive of the Embankments in the 20th and 27th Miles Rs 1.14.0 per 1000 Cubic feet, but that is no

some

Some Miles this rate will be exceeded and especially in such parts as present partially formed Kunkur.—

"Then from the 60th to the (end of the Division) 100th Mile considering the great prevalence of the coarse Soil; the greatly increased rates of Contingent Ex-=penses to the absolute outlay on the labor of Excavation; and also to the difficulty Experienced in either obtaining Contractors or laborers by Lieut Hutchinson in that part of the Canal lying below my Division, I cannot but anticipate a rate somewhat higher than the above, and therefore beg to put it at 2 Rupees per 1000 Cubic feet.—

"In the above calculations I have taken into consideration the positive value of Kunkur if Separated from the Earth, for which I pray extra for obtaining it so Separated, crediting the Ex-=cavation with the value of it.—

"I must further add that the Contractors who have made payment to the Laborers in Ex-=cess of the Sums stipulated for in their agreement papers, are in no case scarcely able to make such sums good, and that, therefore, there will be a loss in this part of the works which will I fear amount to from 700 to 800 Rupees"

The above gives a fair account of the difficulties which occured in the early part of progress on this line of the Excav=vation — Lieut Hodgson's intentions in

in fixing low rates were deserving of all Commendation, and although he failed in so far that an increase was inevitable, the effects arising from the Enquiries that this low-ness of rate led to, were undoubted-ly favorable to his ultimate pro-gress. After all, the rates which were determined after so much enquiry and experiment, were near-ly those of my original Estimate, which amounted to 2 Rs per 1000 Cubic feet.-

Borough

The remarkable fact in this division was that contracts were taken by men who apparent-ly had never undertaken work of the sort in their lines, who were perfectly ignorant of the cost of excavation, and who trusted entirely to their tukdeer (destiny) for for-tunate results.. The failure above described by Lieut Rodgson is a remarkable example of this infatuation; the conduct of these people would in England have been called Knavery, and the Su-pervisor who did not take ad-vantage of it would in all probability have been found fault with.. Lieut Rodgson & might certainly have left these Contractors with their written agree-ments to suffer the loss themselves, but he acted judiciously in not doing so, and his proceedings in this case did in all probability do more towards rendering his board of works acceptable to peo-ple, who were by no means ready to join them, than anything else that he could have done.. The men in

in fact who failed on this occa-
-sion, succeeded afterwards, and
Lieutt Hodgson had nothing to
regret in leaning to the favorable
side of the question in these early
failures.—

The rates at which work
has been executed under Lieutt
Hodgson in the first Hundred
Miles of the Cawnpoor Terminus,
will be seen by the following Ta-
-ble, ~~which does~~ said considering the
difficulties to which I have drawn
attention they are very fair and reason-
-able.—

Locality	Rate per 1000 Cubic Feet		
From 1st to 28 1/2 Mile	1	11	8
" 36 to 50 "	1	10	11
" 50 to 75 "	1	9	10 5/8
	1	12	9

As a general rule the berms
or Towing Paths have been main-
-tained on a level parallel with
that of the Canal bed.— Deviations
from this rule have only been al-
-lowed in extraordinary cases
where a great saving of expendi-
-ture would be ensured; in such
cases the higher levels were gained
by very long slopes, the rise and
fall of which are almost imper-
-ceptible.—

From the 100th Mile to the
Terminus at Cawnpoor the Ex-
-cavation was commenced in
the cold weather of 1848-9 by
Lieutt C.W. Hutchinson of the
Engineers, who on his departure
on medical certificate in Septem-
-ber 1852 made over the works to
Lieutenant Hodgson.—

Lieutt Hutchinson's inter-
-ruptions

ruptions were a repetition of those which have been before described, with perhaps additional difficulties in procuring laborers. The tract of Country over which this line of works was carried extended through the Fattiguh and Canonpoor Districts 26 miles of the former and 4½ of the latter The Fattiguh District was very similar to that described as existing in the first 100 Miles of the course of this terminal line, intersected by a good deal of woods and waste land, but richly cultivated elsewhere; waste land was not so prevalent in the Canonpoor District, the greater portion of the Channel passing over Country cultivated in a very high degree - Lieut Hutchinson shall describe his own impressions on the interruptions which he met with, as stated officially to me in a letter dated 1st February 1831

"As regards Excavation of the Canal, you observe "that this "is a thickly populated District, "and that therefore we should "experience no difficulty in procuring men". The Canonpoor District is a thickly populated one, and it is also most prosperous and fertile; the laborers for the most part are well off, and will not leave their fields to work on the Canal; very many have left the District and gone to the divisions of the Canal further west, as the impression appeared strong amongst them, that the rates there gave greater chance of profit - When we first commenced excavation

Excavation, the rates we held out, Rs 1.. 2.. 0 per 1000 Cubic feet, were undoubtedly too low, and the report spread that here there was no profit to be made. This completely stopped our works for a time, and it was not till August 1850, that we may be said to have got over this impression and commenced work giving higher rates. Since then the work has been progressing and improving rapidly with the exception of about six weeks when our works were nearly deserted by the laborers going to cut the Khureef crops. Even now, however, Squads of Laborers frequently leave their work to go for a few days to any fair or wedding, and then come back again. If a days rain falls, the works are deserted and it takes a few days to collect them all again. I would beg also to draw attention to the Military Board's circular No 422 dated 1st October 1850 in which the officer of the Grand Trunk road in this District has shewn that he finds his Earthwork costs him including dressing Rs 1.. 8.. 2 per 1000 Cubic feet; at this rate I could push on work much more rapidly, but I have been endeavouring as much as possible to keep the rates of my work within my Estimate of Rs 1.. 6:: 0.

"I also beg to point out with reference to my rates as compared with the 2nd Division that when the Section becomes so narrow

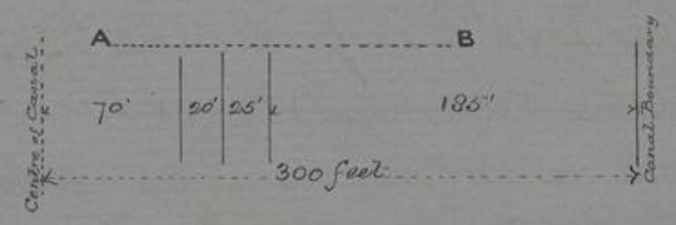
narrow as it does down here, the quantity of dressing and sloping remains the same whilst the proportion of the mass dug in the rectangle is much increased.

Cummins

"For example if the rectangular section be 140 × 9 and width between the Canal boundaries 600 feet..

Dawson

Dwg CLXXIII*



the mean distance earth is carried is AB = 172½ feet

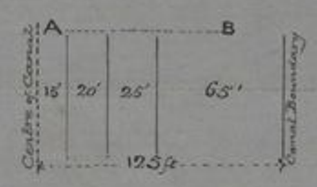
In a mile of Rectangular Channel the Cub. Co is } 140 × 9 × 5280 = 6652800

In a mile of Slopes 9 × 9 × 5280 = 427680

the proportion of slopes to rectangle being 1 to 15·5

"If Rs 1/14 as be the rate fixed for the whole work then 7080480 = Cos Rs 13275. 14. 0; and if we suppose the slopes to cost the Contractor 6 annas per 1000 Cubic feet more, then 427680 Cubic feet at 6 annas per 1000 = Rs 160. 5. 0

"When the average section is as here 30' × 9 and width of Canal land 250 feet..



Dwg CLXXIII*

The mean distance Earth is carried is AB = 85 feet..

In a mile of rectangular Channel the Cubic Contents } 30 × 9 × 5280 = 1425600

In a mile of Slopes 9 × 9 × 5280 = 427680

(the same in both cases) the proportion of Slopes to rectangle being 1 to 3·3 — If Rs 1/6/0 be the rate fixed

fixed for the whole, then 1853280 Cubic feet = Rs 2518..4..0, and supposing the Slopes to cost as much more in this case as in the other viz 6annas per 1000 Cubic feet, then 427680 Cubic feet at 6annas per 1000 = Rs 160..5..0.-

" In the one case the Contractor deducts from his profits Rs 160..5.0 from Rs 13275..14..0, and in the other Rs 160..5.0 from Rs 2518..4..0

"There is no doubt that the sloping and dressing is the most expensive part of the work, and my object in making the above rough calculation (which is of course not actually correct as I do not know the rates or Section of the 2nd Division) is merely to shew that the quantity of sloping and dressing is the same everywhere, and how small in proportion it bears in a wide Section to the mass of digging in which profit is made, as compared with the proportion in a narrow Section. The distance of earth thrown in the first case is double that in the second, but if the rates are as I have calculated them Rs 1/14/0 there and Rs 1/6/0 here, I consider that 8annas per 1000 Cubic feet is too large a difference for the mere carriage of earth 85 feet On this point however I am not certain; if this is as I suppose too large a difference, it follows that the rates there are more remunerative, than they are here, and consequently the greater difficulty of procuring men and contractors that exist here

here - As I before stated, however, I think that my difficulties as regards excavation are in a great measure overcome, and I trust that this work will now progress rapidly."-

With the exception of the depths of digging in the 2nd Division which were generally speaking much in excess to that noted by Lieutt Hutchinson, his comparison is a true one; there is no doubt whatever that the proportion that the expensive work in slopes and dressing bears to the cheap or rectangular Ex-=cavation, is a matter of great consideration to a contractor, and that he prefers wide channels to narrow ones on this account but where great depths entailing the carriage of earth up steep ascents, and upon long distances as was the case in the 2nd Division were the principal sources of expense and difficulty, there can be no doubt that the cost was comparatively cheaper; this however arose from the pre-=sence of the professional Earth contractors, who took to the Ex-=cavation with a perfect under-=standing of what they had to do; in the Districts below Alligmb the people who undertook work appeared to be in most cases men who had not been previously engaged in excavation, and were actually ignorant of many of the simplest parts of the pro-=fession; this led to the necessity of a supervision and watching

for

for which with the regular Earth contractor there was no need;- Contingent Expenses unknown in the 2nd Division were, therefore, heaped upon the original contract rates.- In the upper parts of the Canal, in fact, we worked with professedly Educated people, in the lower we had to Educate them ourselves, and to submit to all the disappointments and expenses attendant thereon.—

Before Lieut. Hutchinson left his work in 1852, the greater proportion of the Channel had been excavated, but by his arrangements which were unknown in the upper parts of the Canal of separating the Contracts for Slopes from those of rectangular digging, he left to his successor a legacy which in effect was like that of which he complains in his comparison of rates; he ~~in fact~~ had completed the greater proportion of the cheap digging or rectangular section, whilst he left to his successor the completions of the Slopes, or that portion of the work upon which he in his comparison above given, places 6 annas in addition to his Estimated rate for excavation.- Although, therefore, Lieut Hutchinson's Bills as submitted, shewed that he had done work at Rs 1.. 7.. 2:7 per 1000 Cubic feet, and, therefore, had worked very closely with his Estimate, he left to his successor the onus of doing the more ex-
-pensive

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= ponsive portions unaided by the relief which a fair proportion of rectangular digging would have given to him — Lt Hodgson had in fact to complete a great detail of finishing off of Berms and Banks as well as Slopes, the whole of which had been left incomplete —

Hull

The Berms or Towing paths are constructed on the same plan as was adopted in the upper part of the Canonpoor Terminal; as a rule they were made parallel to the Canal bed; where this was not the case, the rise and fall were made as gradual as possible

The rates of excavation as submitted by Lieut Hutchinson were as follows:—

Average rate all over Lt Hutchinson work —	1	7	2·7	per 1000 Cubic feet

Since August 1852, as I have before noted, the whole of the Executive Management of the Canonpoor Terminal line was assumed by Lieut Hodgson, whose work has been executed at the following rates

First 20 miles	2	6	..	per 1000 Cubic feet
31st to 65 do	2	5	8¾	

In excavating the Escapes the rates for digging have been Rs 1.. 6. 3 per 1000 Cubic feet, whilst those for the Embankments Works in connection with the Rinde have

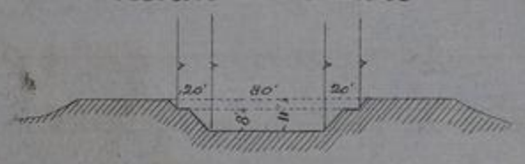
from

from the nature of the works which required consolidation, and the use of ramming and water have been as high as Rs 5..0.0 per 1000 Cubic Feet

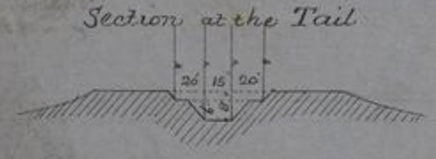
Section IV. Etawah Terminal Line

The Excavation on this Channel, the Extreme dimensions of which are shewn in the following Diagrams

Diag: CLXXIV
Section at the Head



Diag: CLXXV
Section at the Tail

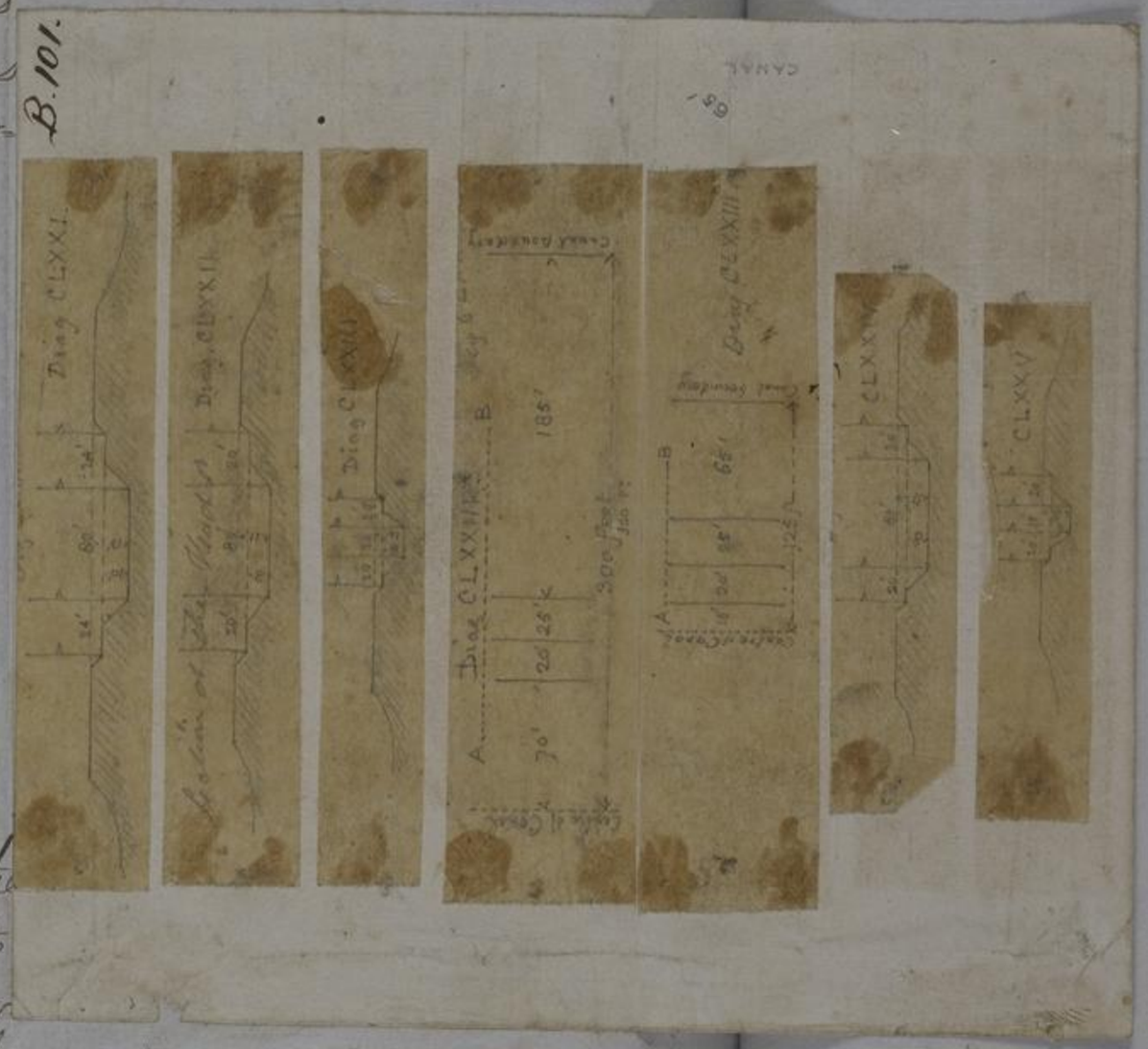


did not commence until 1830

The works therefore had the advantage of the experience that had been gained on the Cawnpore Line; the people too in the neighborhood were prepared in some measure for the system that would be adopted, as well as for the rates that would be allowed for Excavation. The Executive Officer in charge moreover, had had experience on the Jumna Canals. The rates which had been fixed in my Estimate of 1830, were those which had been determined on by Lieuts Hodgson and Hutchinson, viz^t, where the width of the Rectangular Channel was from 80 to 64½ @ Rs 1/14/0 per 1000
64½ to 40 @ " 1/10/0 "
40 to 20 @ " 1/6/0 "

It

B. 101.



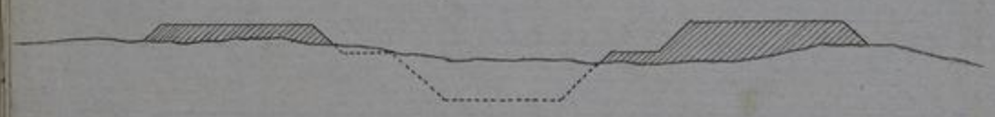
It will be recollected that for a distance of 65 Miles this line runs parallel to and within 5½ Miles of the Cawnpoor Terminal, and that in advance it proceeds through Districts either bordering upon or the same as those traversed by it.. The rates of work might, therefore, be supposed to be the same.. In the Etawah as on the Cawnpoor Excavation the rates fixed on appear to have been insufficient, every care has been taken to keep them as closely to the Estimates as possible, and from what I have observed I believe that ceteris paribus, the rates at which the work has been executed on these lines are very good Specimens of the true cost of Channel digging, limited to measurements of which the dimensions of the above sections are the extremes.

In laying out the daybels or lines upon which the excavation was made, it had been usual to fix wooden pins at distances for the purpose of determining the level of the Canal bed, of the berm, and also that of the Embankment; these wooden pins were very subject to disarangement, they were constantly knocked down by Cattle, and were generally stolen by the village people; they were moreover, after all but an imperfect guide to the Contractor. Lieut. Whiting discarded the detached pins excepting for the head levels, and at every 500 feet in length of the Canal Channel, built up so much of the Bank and Berm as

fell

fell above the surface level of the country, in the form of a rib, or former, so that at short distances along the whole line there existed previously to the commencement of excavation the true outline of the Banks and berms as they were to be constructed at that particular point; taking a section of the country, therefore, upon which a contractor was set to work, its appearance was as follows:-

Diag: CLXXXVI



The shaded lines shewing the rib or former, the dotted that portion of the work which had to be excavated. In proceeding down the line of works therefore, where no excavators had been placed upon them, these ribs exhibited at a glance the amount of Channel to be excavated, and shewed clearly where the berms corresponded with the surface, or where Embankments and raised towing paths had to be made. In making these ribs or fixed marks, a trifling expense was incurred in the first instance, and a good deal of supervision on the part of the Surveyor; but they were amply compensated for afterwards by the facilities with which levels were recognized, and the method and order with which the whole work was done. I may observe that the pins which in former cases had been

been exposed were embedded in the Earth work of the rib, so that the top of the pin acted as the true level or bench mark.. The above plan originated with Lieut Whiting, and I consider it to be one well worthy of the consideration of those who may hereafter be engaged in Canal Excavation. —

Graham

The berms or towing paths are laid out on the same design as those described on the Cawnpoor Terminal, i.e. with a few exceptional cases, they are parallel to the bed of the Channel, and on an uniform scale throughout. —

The soil is very similar to that described as existing on its sister branch to Cawnpoor, tracts of oosur alternate with richly cultivated land, the latter predominating in the Etawah and Cawnpoor Districts. Here also Kunkur both in mass, in gravel strata, and in pieces of the rock mixed indiscriminately with the soil, were met with in equal abundance; the soil, moreover, appears to have the same non absorbent or retentive qualities that I have noted as so remarkable on the Left of the Rinde River. —

I have mentioned that the progress of excavation on the Etawah Terminal line is more backward than elsewhere, in consequence of the lateness of the period at which it was commenced; on my last Inspection, however, in December 1853, the Channel and Embankments had been completed as far as the

60th Mile; considerable advance had been made as far as the 110th Mile; and work was in progress down to the 130th Mile; beyond this no excavation had been commenced upon.—

The rates of Excavation are shewn in the following Table.—

Locality	Rate per 1000 Cubic feet
From 1st to 20th Mile	1 9 6
" 20th to 40th — do	1 9 3
" 40th to 60th do	1 8 8

In looking at the rates and difficulties of procuring & labores on the Terminal lines especially that one bearing upon Caunpoor; In recurring also to the observations made by the Engineers on the Remunerative value of the Excavation to the Contractors, in wide over narrow Channels; where although the rectangular digging in the one is much greater than that in the other, the Slopes, embanking and the more expensive parts of the work are common to both; I will in concluding this Chapter remark, that in the Channel Excavations of the Eastern Jumna Canal three fourths of which were done by me between the years 1825 and 1830; partly by Contract and partly by daily labor, the former being undertaken in most cases by the Oude tribes, the latter (which was only carried on in the immediate neighborhood of my own or the European Superviors Encampment) by the labores of the villages close at hand.

The

The rates were as follows, and they were determined by the Superintend-ent of the works on the nature of the Soil, and on the facilities for Excavation, without any reference to dimensions; Where the soil was Sand (although the Channel was wider) the rate was lower than that where the digging was exe-cuted in clay.- For instance the fixed rates of contract were from the village of Sunkuni to the Jumna at Delhi (a distance of 111 Miles) the rectangular width of Channel at the two Extremes being 30 and 15 feet, Rs 1.. 8.. 0 per 1000 Cubic feet; From Sunkuni upw-ards where there was nothing but Sand although the rectangular Channel varied from 30 to 60 feet in width, the rates were diminished to Rs 1.. 4.. 0 per 1000 cubic feet, nor were these rates exceeded in the daily labor.- These contracts inclu-ded the making and forming of the Embankments, berms and Slopes and no contractors accounts were Settled until his full contract which equalled 1000 feet in length was com-pleted, and accepted as such by the European Supervisor.- This low rate of Rs 1.. 4.. 0 was even extended up to the Nyashuhur Regulator and through at least 4 Miles of Shingle digging —

I believe that in both of these cases it would have been cheaper to have paid double the money, and to have done the work either by daily labor, or by employing more Supervisors to have had a greater check upon the contractors.-

It

It was quite impossible where the soil was hard, and where it came out of the Excavators hands in lumps, to get the lumps beaten up so that the Embankments might be properly made.- It was wonderful the ingenuity with which bad work was concealed by a superficial coating of well broken up soil. But it was by no means wonderful to see the effect that this bad work had on our after prospects: Beautifully perfect as the Sections appeared when given over by the Contractors, rainy season after rainy season produced its effects in exposing the hollowness of the work. It is a fact that these banks which are now in such excellent order, and which offer one of the best roads and the pleasantest Drives or rides in these Provinces, were ten years before they were properly consolidated, and free from the annoyances of holes The Ganges Canal Embankments and earthwork may have been more expensive in the first cost, but eventually, they will be cheaper in every respect than those of the Eastern Jumna.—

Withdrawn

Current Expenses

This Chapter may be divided into 2 Sections - viz^t:
I. Establishment
II. Ordinary Repairs

CHAPTER XI.

Section I Establishment

The detail of Establishments as specified in Appendix D (vide Volume of Tables) was very closely observed during the whole of the Operations - Where this was departed from, circumstances of a peculiar nature may be traced, as in the Northern Division where the constantly increasing amount of works rendered increase of Accountants necessary; and in the 2nd Division where from want of assistance to the Executive, and the necessity for his time being occupied more than usual in Field duties, a more highly paid, and more efficient head to his Office, became necessary - The rules, however, laid down in the above table were maintained as closely as possible, and the Amount of Establishment then fixed, was considered to be the standard in each Division -

The State of the Establishments during the working period may be understood from the following Tables, which Shew in juxtaposition the number of men and amount of pay of each which existed on the 1st January 1868 and the 1st January 1874; viz^t: On the

the dates exhibiting the two extremes of the working operations, under my Superintendence.—

1st January 1848

Northern Division Works

No	Description	Rate	Amounts	Total
1	Ex: Engineer	~~100/~~	400	
1	Assistant	~~100/~~	400	
2	Do	250/	500	
1	Do	~~200/~~	200	
2	Ass[t] Overseers	65/	130	
1	Accountant	~	100	
1	Clerk	~	45	
1	Do	~	40	
1	Do	~	25	1820 .. ..
1	Native Surveyor		30	
1	Moonshi		30	
1	Treasurer		20	
2	Sowars	15/	30	
3	Duffadars	6/	18	
12	Burkindauzes	4/	48	
3	Chupnassies	5/	15	
4	Classees	4/	16	207 .. ..
1	Bricklayer Mistri		20	
1	Carpenter do		14	
1	Smith do		12	46 .. ..
1	Moonshi		10 ..	
1	do		9 ..	
1	do		8 ..	
1	do		7 ..	
4	Chupnasies	5/	20	
1	do		4	58 .. ..
	Total Comp[y]'s Rupees			2151 .. ..

(Materials)

1	Exec: Officer	—	300	
4	Ass[t] Overseers	65/	260	
1	Accountant	—	100	
1	Clerk	..	45	705 .. ..
1	Moonshi		30	
2	Duffadars	6/	12	
8	Burkindauzes	4/	32	
2	Moonshis	10/	20	
2	Do	8/	16	
4	Chupnassies	5/	20	
2	do	4/	8	138 .. ..
	Total Comp[y]'s Rupees			843 .. ..

1st January 1854

Northern Division Works

No	Description	Rate	Amounts	Total
1	Ex: Engineer		600	
3	Dy Superintendents	400/	1200	
1	Do		300	
2	Do	200/	400	
3	Ass[t] Overseers	65/	195	
1	Head Clerk		150	
1	Accountant		120	
1	Clerk		80	
1	do		60	
1	Librarian		20	3125 .. ..
1	Native Surveyor		30	
1	Moonshee		30	
1	Treasurer		20	
1	Ass[t] do		10	
2	Sowars	15/	30	
4	Duffadars	6/	24	
16	Burkindauzes	4/	64	
2	Chupnassies	6/	12	
2	do	5/	10	
4	Classies	4/	16	
1	Chokidar		4 8 ..	
1	do		4	254 8 ..
1	Bricklayer Mistri			25 ..
6	Moonshees	10/	60	
7	Chupnasies	5/	35	95 .. ..
	Total Comp[y]'s Rupees			3499 8 ..

Whole Materials

1	Exec: Officer		300	
4	Ass[t] Overseers	65	260	
1	Accountant		100	
1	Clerk		45	705 .. ..
1	Moonshi		30	
1	Treasurer		20	
5	Moonshees	10/	50 ..	
2	Duffadars	6/	12	
2	do	5/	10	
14	Burkindauzes	4/	56	
1	Chupnassy	6/	6 ..	
6	do	5/	30	214 ..
	Total Comp[y]'s Rupees			919 .. ..

Second Division — 1st Jan[y] 1848

No	Description	Rate	Amounts	Total
1	Exec Engineer		400	
1	Ass[t] Do		250	
1	Do Do		200	
2	Ass[t] Overseers	65/	130	
1	Accountant		100 ..	
1	Clerk		45	1125 .. ..
1	Moonshi		30	
1	Native Surveyor		20	
1	Do Doctor		15	
2	Sowars	15/	30	
2	Duffadars	6/	12	
20	Burkindauzes	4/	80	
1	Chupnasi		6	
2	do	5/	10	
	Carried over Cos Rs		203	1125 .. ..

Second Division — 1st Jan[y] 1854

No	Description	Rate	Amounts	Total
1	Exec: Officer		500	
1	Dy Superintendent		200	
1	Acting Do		220	
1	Overseer		85	
3	Ass[t] do	65/	195	
1	Accountant		150	
1	Clerk		55	
1	do		25	1430 .. ..
1	Moonshi	30/	30 ..	
1	Ass[t] do		10 ..	
1	Native Doctor		15 ..	
1	Treasurer		20 ..	
1	Ass[t] do		10 ..	
2	Sowars	15/	30	
	Carried over Cos Rs		115	1430 .. ..

1st January 1828

Second Division Contd

No	Description	Rate	Amount	Total
	Brot: over Cos Rs		203	1125 .. ..
4	Classies ____	4/	16	
1	Treasurer ____		20	
1	Asst ___ do ____		10	249 .. ..
1	Bricklayer Mistry		15	
1	___ Do ___ Do ___		10	
1	Carpenter - do ___		12	
1	Smith ___ do ___		12	49 .. ..
4	Moonshies ____	10/	40	
4	Chuprassies ___	5/	20	60 .. ..
	Total Cos Rupees			1483 ..

Third Division

No	Description	Rate	Amount	Total
1	Exec: Officer ____		400	
2	Assistants ____	200/	400	
1	Clerk ____		40	840 .. ..
2	Native Surveyors _	10/	20	
1	Moonshi ____		20	
2	Sowars ____	15/	30	
1	Duffadar ____	6/	6	
1	___ Do ____		5	
7	Burkindaages ___	4/	28	
1	Moonshi ____		8	
2	Classees ____	5/	10	
2	___ Do ____	4/	8	135 .. ..
			975.00	
	Total Cos Rupees		975 ..	

1st January 1834

Second Division Contd:-

No	Description	Rate	Amount	Total
	Brot: Over Cos Rs		115	1130 .. ..
2	Duffadars ____	6/	12	
20	Burkindaazes _	4/	80	
1	Chuprassi ___		6	
2	___ do ____	5/	10	
4	Classies ____	4/	16	239 .. ..
1	Bricklayer Mistri		15	
1	___ Do ___ Do ___		10	
1	Carpenter Do ___		12	
1	Smith ___ Do ___		15	52 .. ..
6	Moonshies ___	10/	60	
7	Chuprassies ___	5/	35	
4	Duffadars ___	6/	24	
24	Burkindaazes.	4/	96	215 .. ..
	Total Comp^ys Rupees			1936 .. ..

Third Division

No	Description	Rate	Amount	Total
1	Exec: Officer ___		500	
1	Dy Superintdt ___		300	
1	___ Do ____		100	
2	Asst Overseers _	65/	130	
1	Accountant ___		80	
1	Clerk ____		50	
1	___ do ____		40	1200 .. ..
1	Native Surveyor		25	
1	Moonshi ____		30	
1	Treasurer ____		20	
1	Asst: - do ____		10	
1	Native Doctor ___		15	
2	Sowars ____	15/	30	
1	Jemadar ____		8	
2	Duffadars ___	6/	12	
20	Burkindaazes -	4/	80	
3	Chuprassies ___	5/	15	
4	Classies ____	4/	16	261 .. ..
1	Bricklayer Mistri		15	
1	___ Do ____		10	
1	Smith ___ do ___		15	
1	Carpenter ____		12	52 .. ..
2	Moonshies ___	10/	20	
2	Chuprassies ___	5/	10	
2	Burkindaazes _	5/	10	
6	___ Do ____	4/	24	64 .. ..
	Total Cos Rupees			1577 .. ..

1st January 1828

Cawnpoor Terminal Line

Fourth Division

No	Description	Rate	Amount	Total	Grand Total
1	Exec: Engineer		400		
1	Assistant		200		
1	Clerk		45	645	
1	Native Leveller		20		
2	Sowars	15/	30		
1	Duffadar		6		
1	do		5		
7	Burkindauzes	4/	28		
2	Chupraasies	5/	10		
1	Do	4/	4	103	
1	Carpenter Mistry		10		
2	Mason do	8/	16	26	774

Sixth Division

No	Description	Rate	Amount	Total	Grand Total
1	Exc: Engineer		400		
1	Assistant		200		
1	Actg do		220		
1	Clerk		45	865	
2	Native Levellers	10/	20		
1	Moonshi	15/	15		
2	Sowars	15/	30		
1	Duffadar		6		
4	Burkindauzes	4/	16		
1	Chupraasi		5		
2	do	4/	8		
4	Clarcies	4/	16	116	
1	Smith Mistry		12		
1	Carpenter do		12		
1	Mason do		12	36	
1	Moonshi		10		
2	Chupraasies	5/	10		
-	Duffadars	-	-		
4	Burkindauzes	4/	16	36	1053
	Total Comp'ys Rupees				1827

Etawah Terminal Line

Fifth Division

22 593; V.ii. 1 At. iii. ch. xi.

Tony

1st January 1837

Cawnpoor Terminal Line

Fourth and 6th Divisions often amalgamated under the designation of the Fourth Division

No	Description	Rate	Amount	Total	Grand Total
1	Exc: Engineer		600		
2	Dy Superintds	200/	400		
1	Do		150		
2	Subs: Civil Engineers	100/	200		
5	Ass: Overseers	65/	325		
1	accountant		60		
1	Clerk		45		
1	Do		25		
1	Do		20	1825	
2	Native Levellers	20/	40		
2	Do.	16/	32		
1	Moonshi		15		
1	native Doctor		12		
2	Sowars	15/	30		
1	Treasurer		12		
1	Jemadar		8		
2	Duffadars	6/	12		
20	Burkindauzes	4/	80		
1	Chupraasi		6		
2	Do	4/	8	270	
1	Carpenter Mistri		16		
1	Mason do		15		
1	do do		8	39	
7	Moonshies	10/	70		
2	do	8/	16		
13	Chupraasis	5/	65		
2	do	4/8	9		
4	do	4/	16		
9	Duffadars	5/	45		
27	Burkindauzes	4/	108	329	
	Total Comp'ys Rupees				2163

Etawah Terminal Line

Fifth Division

No	Description	Rate	Amount	Total	Grand Total
1	Exec: Engineer		600		
3	Dy Superintendents	200/	600		
3	Ass: Overseers	65/	195		
1	Accountant		80		
1	Clerk		45		
1	do		25	1545	
1	Moonshi		30		
1	do		15		
2	Native Levellers	20/	40		
1	do Doctor		15		
2	Sowars	15/	30		
1	Treasurer		20		
2	Jemadars	8/	16		
5	Duffadars	6/	30		
3	do	5/	15		
41	Burkindauzes	4/	164		
6	Moonshies	10/	60		
1	Chupraasi		6		
13	do	5/	65		
4	Clarcies	4/	16	522	
1	Carpenter Mistry		15		
1	Mason do		12	27	
	Total Comp'ys Rupees				2094

Alder

The Establishment shewn in the above Table for the 4th and 6th Divisions on the 1st of January 1834 is that which was found to be sufficient after the Amalgamation of these Divisions, and after the whole line constituting the Campoor Terminal had been placed in charge of Lieut Hodgson of the Engineers. An inspection of the Table will shew that the reduction chiefly consisted in Office Establishment

It will be understood that the Establishments above referred to, were dependant entirely on the progress and completion of the works, as well as on the amount of work in hand, and that when this work was completed, and the Canal Channel had received water, an entire revision not only of the Establishments themselves, but of the Divisions or Districts connected with Irrigation, would necessarily follow.—

In arranging for the extent of Divisions over which Executive Officers had control during the progress of works, attention was directed to the magnitude and extent of these works; to keeping the duties of each Executive as compact as possible, and to other circumstances of a local nature which at the time presented themselves.— On the introduction of water however, and the commencement of its distribution

=tributing amongst the Irri=
=gators, there were other points
to be attended to. It was
considered advisable so to
regulate the lengths of the
Districts, that each Executive
should possess the power of
=regulating his supply of water,
and of holding in his own
hands the means of obtaining
relief to a certain extent from
floods arising from excess of
water in the Canal either from
rain, or from diminution of
Irrigation in parts of the
Canal above his District
~~To effect the above~~ To effect this purpose
it was determined that a
=leading feature in the ~~District~~
arrangements, should be the
possession of an Escape at
the Head of each District,
and that a line of Electric
Telegraph should as early
as possible be carried from
the Nurnoor Fork, situated at
the heads of the Cawnpoor
and Etawah Terminal lines,
along the Canal bank to
Roorkee and the Myapoor
Regulator. - By these means
it was supposed that each
District would in itself have
the power of obtaining relief
by the Escape at the Head
and along the course of its
own Channel, whilst the
Electric Telegraph would enable
the Officer to correspond with
the Districts lying above him
and with the Dams and Escapes
in the Northern regions. Ul=
=timately, wires connected with
the Electric Telegraph reading
Office

Office might be carried along each of the Terminal lines by which means the whole of the works from the Head to the Termini, would be in corres=pondence. - This design if worked out in extenso would undoubtedly place the whole machine in a very efficient state; it appears to me, however, to be indispensable as far as the Telegraph between Nunoor and the Myapoor Head is con=cerned; as by no Establishment that we could devise, would it it be possible to protect our=selves against the inconveni=ence of high floods with such certainty, or with such imme=diate effect, as we could by a well regulated Telegraph. -

The proposed limits of the different Divisional Districts for the Ganges Canal when the water has been fairly admitted and the Rajbuha has sufficiently advanced to enable the Cultiv=ators to commence Irrigation may be thus given as a Sketch of what I would recommend in the early State of progress. -

The 1st or the Northern Division

The District attached to this Division will extend from the Ganges River at the point where the Canal leaves it to the Futtiguhr Branch Head - Its total length is 50 Miles, and it will independently of the Executive charge of the works, embrace the control of the whole of the Irrigation in the Khadir

Khadir, as well as that connected with the Rajbaha Heads at the Assoffnuggur, Muhmoodpoor, Behra, and Paoli Falls. This District will be under the charge of an Executive Officer who under the title of "Superintendent of the Northern "District" will act in the same capacity as the Superintendent of the Eastern or Western Jumna Canals. He will have under his charge the whole of the works, and the control of the Canal Revenue within his boundaries. His duties in fact will correspond with those of the Officers above mentioned, being responsible both for the permanent works of the canal itself, for the efficiency of the Rajbahas, and for the proper Supervision of the water rent. He will annually submit to the Superintendent of Canals N.W.P. the same papers in abstract of the Expenditure and receipts with a Balance Sheet of Gross and Nett returns with reference to Deadstock and dues to Government.

The Head Quarters of the Superintendent will be at Roorkee, and he will have attached to him two Deputies one of whom will be specifically placed on the tract North of Roorkee; the other on the works and Irrigation on the high land stretching from Roorkee to the Futtiguth Branch Head. The duties of these 2 Deputies will possess sufficient variety

to

to enable the Superintendent to form his own selection, founded on the qualifications of the Offi=
=cer. The leading or 1st Sub division, being that which is con
=fined to the Khadir will com=
=paratively speaking be more connected with works than Irrigation, whereas that lying below Roorkee, will have more of the latter than the former. The duties of both Subdivisions however are sufficiently mixed up with Irrigation to qualify an Officer for Canal Revenue duties, a point that I consider to be of great importance in a Department, where the removal of Officers from one Post to another is of constant occur=
=rence, and where a knowledge of Revenue matters as regards Canal Irrigation is as indis=
=pensable as acquirements in Civil Engineering. —

C Dawson

In addition to the Super=
=intendent and his 2 Deputies, Mr Finn who during the progress of the works has con=
=ducted the material Depart=
=ment will retain his situa=
=tion, with the additional du=
=ties of Superintending the Navigation in the Khadir. The object of these double duties is as regards Materials to main=
=tain at the different works a large supply of bricks in store which can be done grad=
=ually by keeping the Village Puzawas or Native Brick kilns in constant progress until a sufficient quantity of material has

has been collected; and with reference to Navigation, to Superintend the lockage and the boating between the Head and the Solani Aqueduct, during the early periods after the water is admitted into the Canal, and when active measures will be required, to transport boulders or River Stone for the purpose of laying down the flooring of the Earthen portion of the Solani Aqueduct. It will be understood from what has been said in Chapter IX, that the Carriage of boulders to the above point, previously to the admission of water was considered to be so far premature, that vast expense would be saved by its postponement until the line was open for boats, by means of which, moreover, a larger and better sort of boulder would be procured from the main Ganges and its branches, than could be forthcoming from the Mountain passes of the Sewaliks The early Completion of these boulder floorings, ~~[illegible]~~, is further indispensable for the satisfactory protection of the Earthen part of the Aqueduct from the wear and tear of the Current; and the deputation of Mr Finn to the especial charge of this duty, appeared to me not only to be likely to accelerate progress, but the employment itself was in a great measure allied to that, in which he has given so much satisfaction previously

The

step

The ~~fact~~, however, of placing the Navigation under the es=pecial management of an Officer, was a guarantee for ~~of~~ its proceeding on a proper foot=ing, and the best means I can think of for ~~=~~establishing in the minds of the native com=munity the advantages that were open to the trader from making use of the water ~~as a means~~ for Transport. — I believe that a few years of steady progress in the use of the Navigable Canal and its lockage on the line between Hurdwar and Roorkee, would be in all probability the certain way of ensuring the ready a=doption of the Canal as a Navigable line elsewhere. —

Including Mr Finn and his Establishment in that of the Northern District therefore; the following is the design of the permanent Es=tablishment that might be considered appropriate. —

Northern District

1 Superintendent
2 Deputy Superintendents. —

Depr Superintendent 1st Sub Division	Head Quarters at Roorkee, but lia=ble to be detached to Hurdwar or any point be=tween that and Roorkee.

Works

4 Overseers — Of whom

1 at Myapoor with a party of
4 Tindals
40 Beldars
In charge of Dam and Regulator, and of the Canal banks from the main Ganges to the Dowallapoor Bridge

Bridge.

1 at the Puttri - with a party of
4 Tindals
40 Beldars
in charge of the Works and Embank-ments lying between the Sowala Nor Bridge and the Upstream extremity of the Dhunowri Revetments.

1 at Dhunowri - with a party of
4 Tindals
40 Beldars
In charge of the Dam and Regulator and of the Canal works and Embank-ments from the Upstream extremity of the Dhunowri Revetments, to the UpStream extremity of the Solani Aqueduct.

1 at Roorkee - with
8 Tindals
80 Beldars
In charge of the Aqueduct and Embankments, with further charge of "Plant" attached to the works, in-cluding Boats, Horses, Wagons, railroad &c.
This Overseer would also be employed in the Station of Roorkee, on the Public buildings, and in the Conservancy Department.

Depy: Superintendent 2nd Sub Division — Head Quarters at Roorkee, but liable to be de-tached to any convenient post between Roorkee and the Futtiguh Branch Head:-

Works viz:-

1 Overseer - who would be detached to either Baira or Dasli, so as to be in the vicinity of the works at the Southern extremity of the District with
1 Tindal
10 Beldars
over each of the Falls viz: those at-
Asso
Anuggur
Muhmoodpoor
Bera
Dasli.
giving a total of
4 Tindals, and
40 Beldars

I may observe with reference to these Permanent Belaur Establishments that I would consider them as entirely probationary — In the Khadir and North of Roorkee where the Population is small, and where the Regulating arrangements at Myapoor and Dhumowri render the presence of a Skilled Establishment indispensable, these Establishments may possibly be of the utmost importance to the efficiency of the works — South of Roorkee, however, the necessity of maintaining large and expensive bodies of Men may be questionable; in the early periods of the flowing of the water they may be useful and under this view of the case it strikes me that they may be recommended subject to after revisions, dependant on the experience gained by dealing with the Running Water. —

Executive Officer of Materials and Superintendent of Navigation

Mr Finn; with a party sufficient for working the Locks and maintaining the Navigable Canal in an efficient state for the passage of the Craft Mr Finn's Office and other Establishment I would leave as it is at present; reducing it as opportunity offered, and as a necessity for so doing arose from actual experience

I would say the same of the Office and Establishment of the Superintendent or Executive Officer; a number of Chuprassies

russies and Subordinate people would necessarily be discharged on the completion of the works; there could not possibly be any use for so great a number as there are at present. The Office which ~~at present~~ now exists was raised for a specific purpose at periods when the accounts and responsibilities of the Executive Officers were enormous. this part of the Establishment I would place on the same footing as it was originally as shewn in the list for January 1818; that list in fact would be the scale upon which the whole permanent Establishment of the Division might ~~be reorganized~~ be reorganized.

The Revenue Establishment must necessarily be regulated by the new code upon which Captain Baird Smith is now engaged, the details of which will greatly modify the existing scale as practised on the Jumna Canals. In the meantime, however, I should consider that a Zilladar and Naib Zilladar for each 50 miles, and a Darogá for every 100 miles in length of Canal Irrigation would be sufficient; the Establishment for collecting being regulated by that now existing elsewhere, with Chokidars at each of the Choki posts.

Under the above plan therefore, the Scale for the European Establishment would be as follows

1 Superintendent of the District
2 Deputies
5 Overseers
1 Executive Officer of Materials, and Superintendent of Navigation

Rohtford

in the person of Mr Finn

The 2nd Division

The District attached to this Division would extend from the Futtigunk Branch Head on the Main Line to the Head of the navigable Cut at the Bhola Falls, situated imme=diately above the Damri Khoord Escape. It would not include any of the Bhola Ma=sonry works ~~with~~ in its ~~limits~~. The whole of the Futtigunk Branch would be included in the 2nd Division; which would therefore consist of 33 Miles of Main Canal in addition to the Futtigunk Branch. The means of regulating the supply in this Division as far as rests with itself, depend on the Futtigunk Branch which lies at its immediate head, and on the Khutowli and Aboos Nulla Escape, which are situated at the 62nd and 69th Miles. The close proximity to the Northern Division, however, gives this Dis=trict great advantages in cor=respondence with the Dams in the Khadir, the lowest of which, viz: that at the Rutmoo is situated 38 Miles North of the Futtigunk Regulators.

At the time that I am writing the Futtigunk Branch has not been excavated: on its completion would depend the future scale of Establishment for the Division. In the mean=time, however, I would lay down the

the same rules here as I have done for the Northern District viz: to adopt the Scale of 1858 revising it to any extent that may appear applicable to the particular circumstances of the case; and with regard to Revenue Establishment confine it within the limit which practical experience has shewn to be efficient on the Dumna Canals.- The Supervising Establishment might be regulated as follows:-

1 Superintendent of the District
3 Deputies.-
4 Overseers.- Lory Pkwd

The district to be divided into 3 Sub Divisions as follows:-

1 Deputy in charge of the main line of the Canal from the Regulating head to the Navigable Head and Rajbuha of the Bhola Falls. with One Overseer attached Lory Pkwd

This Deputy would have charge of the Regulating heads at Jaoli, with a working Establishment on the following Scale for the Gates.-

4 ~~Gates~~ Tindals
40 Beldars Lory Pkwd

For the Falls and Locks at Chitowra and Sulawur, there would also be a working Establishment consisting of

1 Tindal
10 Beldars

over each work.-

For the Escapes at Khutowli and Abod's Nulla, there would also

also be an Establishment of
1 Tindal
4 Beldars
at each work.—

These parties would be considered available for clearance of banks and all contingent demands in their neighborhood, and I would recommend that in defining the boundaries & within which each party was to work, perfect order and & tidyness within those limits should be insisted upon.—

It will be seen that for the charge and management of the Regulators, Falls and Escapes, the above arrangement provides for an Establishment of 8 Tindals and 68 Beldars, a party sufficient to do much useful work if the men are properly looked after.—

I look, however, with & much jealousy on these permanent parties of Beldars; Skilled men are undoubtedly required for working windlasses and managing the Regulation of water, but it may be questionable whether the object may not be gained at a smaller sacrifice of expenditure.— My experience has convinced me that men of this description who are paid by the month, do not work & either in excavation or clearance equal to the daily paid laborer.— The permanent parties, however, secure the immediate attendance of laborers at critical moments, and in the early period after the

the admission of water, this may be a consideration in their favor

The Futtiguh Branch would on its completion engage the attention of 2 Deputies and 3 Overseers, with working Establishments on the same Scale for the Falls and Locks, Escapes, &c., as I have proposed for the Main Canal; by the time however, that this work is completed and supplied with water, sufficient experience will have been gained, to render the Scale of Establishment required for its maintenance quite clear, without any Speculative opinions being advanced at the present time.—

The 3rd Division

The District attached to

This Division will extend from the Head of the Navigable Cut at the Bhola Falls, to the Kasimpoor Escape and Bridge, or from the 83rd to the 166th Mile. It would include within its jurisdiction the Bolundshuhur and Koel & Branches to their confluence near the Town of Katrass; and it would terminate on the upstream end of the Kasimpoor Escape, with which work its Superintendant would, however, have no control.

This District therefore, consists of 83 Miles of the Main Canal: 90 Miles of the Bolundshuhur and 50 Miles of the Koel Branch.—

At the present time neither

neither the Bolundshuhur nor the Koel Branches have been excavated. The working out of any organized system of Establishment would depend therefore on the completion of these works.

Shahaw

The Jannikhoord Es=
=cape which lies immediately at the Head of the Division places the means of Regulating head supply in the hands of the Superintendent. Besides this leading Escape, the Bolund=shuhur and Koel Branches give him further aid in the Control and management of the water, and the Moonda Khera Escape which lies at the 143rd Mile enables him to re=lieve the Canal in cases where the Branches themselves may be overloaded. The means of Escape in the 3rd District appear to me to be well adapted to the circumstances under which it is placed.

For this Division there would be,

1 Superintendent of the District
2 Deputies
4 Overseers

the District would be divided into 2 Subdivisions, each as before under a Deputy Super=intendent.

The 1st Sub Division would extend from the Navigable head at the Bhola Falls to the upstream end of the Moonda Khera Escape and works, on the main line of Canal, with the charge of the Bolundshuhur Branch

Branch.

This Deputy would have charge of the Falls at Bhola and Dasna, as well as the management of the Bolund-Shuhur regulators; he would have 2 Overseers under him One ~~especially~~ special for the charge of the Jamni Khoord Escape and the Bhola Falls - For the former I would give the same working Establishment as before noted, viz^t. 1 Tindal and 10 Beldars for each of the Falls; 1 Tindal and 4 Beldars for the Jamni Khoord Escape; and for the Regulators I would give 4 Tindals and 40 Beldars -

The 2^nd Sub Division would extend from the Moonda Khera Escape and works (including those works) ~~in this Sub division~~, to the end of the District or to the upper end of the Kasimpur Escape. ~~with~~ The Kool Branch would also be included in this Sub division.

This Deputy would have charge of the Moonda Khera Escape, of the Falls at Pulra and Simra, and of the Regulators at the Head of the Kool Branch - with 2 Overseers under him. -

The working parties at the above works would be as follows: -

Moonda Khera Escape.	1 Tindal 4 Beldars
Falls at Pulra	1 Tindal 10 Beldars
Do at Simra	1 Tindal 10 Beldars
Kool Regulators	3 Tindals 30 Beldars

I would make the conditions on which the maintenance of this permanent Establishment

Establishment rested, similar to those above described; the Establishment of Tindals and beldars as fixed Establishment should in fact be experimental.

The Superintendents Office and Divisional Establishment I would determine on the Scale of 1848 revised agreeably to circumstances; and the Revenue arrangements would be formed on the Scale of the Summa Canals. i.e. 1 Daroga to each 100 miles in length of Channel, and 1 Zilladar and 1 Naib Zilladar to every 50; with Chokidars at the different Chokies and Subordinate Establishment on the Scale which has been found to answer elsewhere.—

The 4th or Southern Division

This District would include that part of the main Canal extending from the Kasimpoor Escape to Nanoor, or from the 166th to the 180th Mile, in addition to the Terminal lines running towards Lawnpoor and Etawah.—

The Kasimpoor Escape would be the leading Regulator of the Supply in this District; the Escapes on the Terminal lines, and the Regulating Bridges at the Heads of the Terminal lines, acting subordinately for similar purposes.

The Supervising Establishment would consist of

1 Superintendent of the District
2 Deputies
7 Overseers —

As this District is of a much greater extent than the others, especially in its connection with the Ratnass Irrigation, I would classify the Deputies under 2 Heads making One a 1st Class on a higher Salary of 300 Rupees, and the re=maining 3, Second Class on the usual Salary of 200 Rupees per Month. —

The 1st Class Deputy should have immediate charge of the Kasimpoor Escape, and the Nanoon Regulator, with the intermediate line of Canal and its Irrigation under the denomination of the 1st Sub Division. —

The 2nd Class Deputies should hold Sub Divisions as follows: —

2nd Sub Division From the Nanoon Regulators along both of the parallel lines of Canal extending to the Bridges on the High road between Mynpoori and Etawah. —

3rd Sub Division From the Bridge on the Mynpoori and Etawah Road on the Canonpoor Ter=minal line to the end at Canonpoor

4th Sub Division From the Bridge on the Mynpoori and Etawah Road on the Etawah Terminal line to the Jumna. —

The 1st Class Deputy in charge of

of the Nanoon Regulators would have under him the following permanent working Establishment —

Kasimpoor Escapr	1 Jindal
	4 Beldars
Nanoon Regulators	2 Jindal
	20 Beldars

Comments

The 1st Class Deputy would comparatively speaking hold a subdivision of small extent, but he would be available for more extended duties on the requisition of the Superintendent. —

I would here as elsewhere maintain the Establishment of the 4th and 5th Divisions on the Scale of 1848, revising them to meet the nature of the Supervision and work which experience might point out to be necessary. —

For the Revenue and management of Irrigation I believe that Captain Baird Smith's new code will be prepared long before water is brought with any regularity upon the Nanoon Regulators, in which case the Scale now adopted on the Dumna Canals for Collection and Irrigation Establishment, and which I would recommend as a starting point here, would be superseded. It appears to me unnecessary, therefore, to speculate on the precise detail of subordinates that may be required hereafter, by adopting that which was in

in force in 1818 both as regards Office and working Establish=ment, a reasonable Scale upon which we can base any after modifications appears to be pro=vided.

Looking therefore to the Statement for 1818, given in the early part of this Chapter as that which provides a Scale for both the Office and working Establishment of each of the proposed Districts, I may in recapitulating the European Establishment required for each, and the length of Canal in Miles which each Superintendent has to control, give a distinct idea of the distribution of the Executive, who in direct corres=pondence with the Superintendent General would supervise the works, and manage the Irri=gation of the Ganges Canal.

^*

Superintendent General

1st or Northern District

1 Superintt^do
- 1st Sub Divn: 1 Depty Superintt^do and 4 Overseers. above Roorkee distance 19 Miles
- 2nd Sub Divn: 1 Depty Superintt^do and 1 Overseer. below Roorkee distance 31 Miles

(from The Canal Head to the Futtiguhs Branch Head 50 Miles)

1 Executive Officer of Materials & Supt^do of Navigation from Canal Head to Roorkee.

2nd: or Saboli (upper Centrical) District

1 Superintendt^o
- 1st Sub Division. 1 Depty Superintt^do and 1 Overseer. In charge of Regulating Heads & Main Line of Canal to the Navi=gable Head at the Bhola Falls. 33 Miles
- 2nd Sub Divn: The Futtiguhs Branch in which 2 Deputies and 3 Overseers would be employed. 165 Miles

(Total Length of District: main 33, Branch 165, Total 198)

3rd

* I may however remark that altho' in the preceding details, as well as in the following Summary I have fixed the scale of number and grades of Dept^o Supt^dts at the lowest possible point; I am of opinion that it would add to the efficiency of the branches if it were to be understood that in cases of high merit each Divn might have an 1st Class Deputy, not of necessity, but as a stimulus to exertion, or reward for good work done.

3rd or Bolundshuhur (Lower Centrical) District

1 Superintendt

1st Sub Divn: 1 Depy Supdtt with 2 Overseers - From the Bhola Falls to the up Streams end of the Moonda Khola Escape, with charge of the Bolundshuhur Branch — 150 Miles

2nd Sub Divn: 1 Depy Supdtt with 2 Overseers - From the upStreams end of the Moonda Khola Escape, to the upStreams end of the Kasimpoor Escape, with the control of the Koel Branch and its regulation Distance 73 Miles -

Length of District
Main Line 83
Bolundshuhur Branch 90
Koel do 50
Total 223

4th or Terminal District

1 Superintendt

1st Sub Divn 1. 1st Class Deputy Supdtt: with 1 Overseer From the upper end of the Kasimpoor Escape to the Nanoon Fork including the Regulators at that Point 14 Miles

2nd Sub Divn 1. 2nd Class Deputy Supdtt - with 2 Overseers From the Nanoon Regulators to the Mynpoori & Etawah Road on both Terminal Lines - Distance 70 x 2 = 140

3rd Sub Divn: 1. 2nd Class Deputy Supdtt - with 2 Overseers from the Bridge on the Mynpoori and Etawah Roads on the Cawnpoor Terminal line to the Ganges at Cawnpoor 108 Miles

4th Sub Divn 1. 2nd Class Deputy Supdtt with 2 Overseers from the Bridge on the Mynpoori and Etawah Roads on the Etawah Terminal Line to the Jumna - 105 Miles

Total Length of District
Main Line 14
Cawnpoor Terminus 170
Etawah do 175
Total 359

The total number, therefore, of European Officers required on the Scale above laid down, independently of the Superintendent General, would be! —

4 Superintendents of Districts
11 Deputy - Do. { 1. 1st Class / 10. 2nd do.
1 Ex: Officer of Materials and Superintendent of navigation
20 Overseers —

With reference to the last item, I would by no means confine the Class of Men holding the situation of Overseers to Europeans - Europeans if selected and

and chosen for their qualifications in being quick at resources, or interested in the peculiar duties on which as Canal Overseers they will be specially placed, are undoubtedly to be preferred; if, on the contrary, they are unselected and placed upon the works as they have been during my + Superintendency merely because they had passed a fair examination at the Roorkee College, I + would sooner have Natives. — + Europeans in fact, unless they have qualifications which enable them to submit to the Solitude of detached District posts without repining; unless they are gifted with energy of character, and quickness at remedying and even anticipating accidents, are in Nine cases out of ten, useless. Unsteadiness of character whether arising from intemperance or neglect of duty is absolutely + ruinous to any works with an active agent like that with which we have to deal, constantly opposed to us. — Running water won't wait upon the indifference of either Sergeant or Corporal, and a Man who won't or can't mount his horse at any period of the night or day, to visit the extreme limits of his Division is utterly unfit for Canal service If Europeans are appointed to this duty they ought to have Horse allowance. I would give each Man 20 Rupees a Month or sufficient for the keep of 2 Horses, and I would place such powers in the hands of the Superintendent

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=intendent General, that neither
should this allowance be mis=
=applied, nor should any European
have the power of retaining his
place one moment after he had
either by drunkenness or neglect
forfeited his claim to the confi=
=dence of the Superintendent of
the District - On the other hand
the Superintendent General ought
to have the power of rewarding
good conduct, and of promoting
to a higher grade in the Depart
=ment those men who signalize
themselves by meritorious conduct
to effect this the Establishment
of Overseers might be divided
into three grades - each Step giving
an increase of Salary - With
regard to a choice between a
European and native in the
Situation of Overseer, my opinion
after very nearly 30 years of canal
Service is, that a good European
is invaluable; a bad one, is
not only worth nothing, but he
is so expensive and troublesome
that his presence on the works
is injurious to their interests, &
and in many cases he becomes
absolutely dangerous, from the
natural tendency that exists to
entrust him with orders, and
to place confidence in his ener=
=gy of character -

The native wants the
energy of the European, and
generally Speaking does not
carry with him weight suf=
=ficient

=ficient, to control his subordinates, but in other respects, he has attri=butes of a very high order, tem=perance, sobriety, knowledge of the people over whom he is placed, and very great intelligence. — During my career I have cer=tainly had less disappointment with natives than I have had with Europeans, a result which is probably arrived at, from the former being more under control, and as such being more subject to summary punishment, than the latter. — The European when once appointed to the Department can only be punished by sus=pension, subject to the orders of the Board, whose position in Calcutta at a distance of a thousand miles, renders im=mediate retribution impossi=ble. — Removal from the Depart=ment can only be effected by a reference by the Military Board to the Head of the Supreme Go=vernment, so that what with one delay and another, I have known a man to remain un=der suspension for nine months, drawing pay and Canal Salary, before any orders were given as to his ultimate disposal. This acts both ways, the Canal Office is restrained from bringing to the notice of his superiors acts which will lose him the service of the only man probably to whom he has to look for carrying on business, with little chance of a speedy settlement of the

Question

Question at Issue; the European
Overseer takes his measures ac-
=cordingly, and if a bad man,
is indifferent to results so fear-
=fully procrastinated.. This ap-
=pears to me to require remedy

Brownlow

In the Canal Department
an Assistant Overseer when ap-
=pointed either from the Civil
Engineers College at Roorkee, or
direct from his Regiment, joins
the Superintendent of a Canal
and is at once sent on detached
duty. There, at a distance from
Society, with a control over na-
=tive Subordinates, and with a
management of works, that
ought properly to be entrusted
to an experienced man only,
the young Overseer has to learn
his duty as well as he can; he
is selected from the Roorkee
College without the slightest
reference to his turn for building
or Civil Engineering; his study
at the College is of books only,
and he reaches the Department
in which as I have shewn he is
immediately called upon to take
up duties requiring knowledge
and experience, as ignorant and
as inexperienced as he could
well be. Under such circum-
=stances, can it be wondered at
that a young raw Barrack
Recruit goes wrong?. The
consequences are fatal to the
unfortunate man in numbers
of instances, the Government works
suffer by all sorts of mistakes
and blunders, and the Executive
Engineer who is held responsible
for the cost and quality of work
done

done, has literally nothing to do, but to look on and bear it. The remedy that I would pro=pose is this, that men when they have passed their exam=ination at the College, should be drafted off in parties of from 2 to 10 in Number, and sent to the Head Quarters of any De=partment or Division of public works, which was most exten=sively employed in building. The Men should remain on probation actively employed on these works under the eye of the Executive Engineer or his assistants, and at the termination of 2 years, his retention in the Department of Public works at all should depend upon his efficiency as a builder, or as an Overseer over buildings; the determination on these points being guided by the report of the Executive Engineer under whom he has been probationarily employed. No assistant Overseer ought to be sent on detached duty until he has passed through 2 Years of probation in actual building under the eye of an Officer.—

The Education of the European Overseer at the present time, is confined to 6 or 12 months reading at the Roorkee College: it is entirely theoretical. Previously to admission he is called upon to pass an examination on the following subjects:-

Reading
Writing
Arithmetic

Arithmetic as far as Vulgar fractions
Elementary Geometry
Mensuration
Simple plan Drawing. -

He is passed out of the College by a process equally easy - he then commences a series of which I have attempted to give an ex-=planation above; Now, why & should not the period be ex-=tended to a further course of practical building at Roorkee, to an acquisition of knowledge on the different details of brick and mortar practice, as called for in the Department of public works; to becoming acquainted with the native terms and ex-=pressions used in the profession that he is about to embrace; to a comprehension of the cost and value of work of different descriptions, and to the general details of matters that must eventually come before him? The 2nd Class of the College & which consists entirely of non Commissioned Officers and men who are intended for the Depart-=ment of public works might, it appears to me, have its & standard of proficiency raised very greatly by some such & modification of the present system. - That this will be done eventually, or in its absence, that the 2 years of Probationary Service should be called for from each Assistant Overseer I hope for with all my heart not merely for the good of the Service alone, but in justice

to

to the Young European, who in the present state of things is not fairly dealt with.—

When an European enters the Department without the ordeal of entering the Roorkee College, his Qualifications are judged of by an examination carried on by a Committee of Engineer Officers, the extent of which is a knowledge of Arithmetic, Mensuration, and an Estimate of the Cubic Content and Cost of a plain banack building. In this case the man on his entering the Department of Public Works is worse off than his contemporary from the Roorkee College; the last is educated and prepared in a small degree, the former in nine cases out of ten has no education at all.

I believe that the deficiencies noted above are as patent to the Public works in general, as they are to the Canal Department. In the latter, however, the posts of Overseers are, with one solitary exception, viz^{t}: at Roorkee, detached from the eye of Officers, and ought not to be trifled with. The men selected for these duties might with the greatest advantage to the State be not only better educated, but be selected for their inclinations leading them to Civil Engineering as a pursuit, and not as a mere change from the routine

Dawson routine of Regimental duty—

Since the Establishment of the Civil Engineer's College at Roorkee, and its division into 3 Classes; the 1st being for the more highly educated, and those capable of being employed on the duties of Sub Assistant Civil Engineers, the experiment has been tried of drafting students of this Class into the Canal Department Four of these young men were placed under the orders of Executive Engineers, and with the exception of one who was removed for indolence and inefficiency, they have got on very well: their duties have been confined to short subdivisions of works in which they have had to survey, lay out, and excavate Canal Channels, form Embankments, and plant trees; they have also had to superintend Masonry works, such as Bridges, drain heads, Chokies, &c. For all these they have to draw out their own plans copied from the Office designs, to return measurements of Cubic content of work, and to submit monthly accounts to the Executive. There are 2 men of this description on the Cawnpoor Terminal line, who have at the present time served 5 years: as far as I can gather from the reports of the Officers under whom they serve, and from my annual Inspections, the work done by these men is equal to that performed under European Superintendence, and as far as building and the correct finishing

finishing of buildings is con-
cerned, better. The only want
that this class of men has, is the
active energy which the European
naturally possesses. Madho Ram
and Petumber Sing, the gentlemen
to whom I allude above, have
shewn themselves highly deserving
of the confidence of the Executive
Engineer, and are good Specimens
of Material which may ultimately
be turned to excellent account
in the Department. The rate
of pay of the Subassistant
Civil Engineer is 100 Rupees
per month, with allowance
when marching equal to 3/10ths
of that Salary.—

The 1st Class which pro-
-duces the Subassistant Civil
Engineer is followed by the
2nd Class, which is especially
devoted to Non Commissioned
Officers and Privates for education
as Overseers; in this Class there
is an unconvenanted Department
which is also intended to supply
the Public works with overseers
and Supervisors. I have before
remarked that great benefit
would be derived from these
Men being made to undergo
a series of practical studies on
construction before they were
allowed to be detached; that
this should be done appears
to me to be indispensable. Men
of this Class, moreover, should
not leave the College until they
had acquired a knowledge of
the technicalities of the Profession
in which they are about to enter,
they ought not only to speak

the

the language freely, but to speak that language which would enable them to hold a conversation with the native mason, Smith and Carpenter; they ought at any rate to know the native name for a 'Brick' or for a "Brick mould"; information, which many of the men now received in the Department of Public works are altogether in=-nocent of - Non Commissioned Officers and Privates on their reach=-ing Roorkee ought not to for=-get that they are Soldiers, and this ought to be instilled into their minds during their edu=-cation at the College; - examples of an utter forgetfulness of Mili=-tary discipline, or I should rather say discipline of any sort, are by no means uncommon and rough reminders are every now and then required, as dis=-agreeable to the giver as to the receiver, to bring to the Soldiers mind that discipline is not dropped in the absence of the Sergeant Major. —

The 3rd class at the Roorkee College is especially for the education of native Surveyors, Draughtsmen, &c; it is in my opinion the most useful division of the College — From hence are derived the numerous native Levellers, Surveyors, and draughtsmen, who are holding posts under the Road Committees, Surveys, Canals, &c; a hiatus has been filled

filled up by the introduction of this class, which has long been the drag upon all progress; Euro= =pean agency was too costly, Exposure to the Sun and climate was a bar to the indiscriminate employment of the European on many out of door duties which are now readily filled up by the natives; & and as draughtsmen, the wonderful perseverance and delicacy of manipulation for which the native is incomparably superior to the Common run of Europeans, render him invaluable either in Mapping ~~and~~ or Plan drawing; whilst the Comparatively low rate at which the native can live in India, and the few wants which his position demands, makes his services available, where the Monthly pay of an European would be entirely prohibitory —

Native Draughtsmen in the Directors Office who have certainly had the advantage of the instruction and Supervision of Mr N. Marten the Head Assistant, whose acquirements as a draughtsman himself are of a very high order; do the whole of the work of Copying and reducing that exists in that Office: the execution of their work is equal to anything that could be desired, and far superior to that of the Common class of European who is available for this purpose in India — A Salary of 200 Rupees a Month or 240 £ a Year, was insufficient to secure a man of the latter class

class, with acquirements of a very ordinary description; whereas the highest Salary in the Directors Office to the Native Draughtsman is 50 Rupees a Month or £60 a year. Many of the Maps and Plans ~~which~~ figured in the Atlas which is attached to this Volume, are done by either Kadir buksh, Wujeeoodeen, or Luthfoola Khan, 3 of the leading men in the Office, and for neatness of execution, and wonderful accuracy of copying (neither one nor the other being acquainted with English any further than the written character) they would not fail in comparison with drawings done by Europeans holding 5 times their Salary.

Hull

Native levellers and Surveyors who are attached to the different Executive Officers, and who draw only from 15 to 25 Rupees a Month, carry on a great portion of the interior Surveys, and cross levels from Bench Mark to Bench Mark; they are invaluable in readily obtaining a small Survey, or a rough configuration of Country, previously to the designing of works, and they relieve the European Officers from the exposure and constantly re-curring labor, that previously to their introduction occupied a great portion of his time.

With the Road Com-mittees they are the means by which the alignements of roads are determined, and frequently in

in addition to the operations of Survey and Mapping, they take an active part in the execution of the works.—

Although the 3rd class in the Civil Engineers College at Roorkee has now been in existence only for 5 years or thereabouts, it has passed out the following Students, who have received employment as below.

Roads and Dep.t Public works 6
Surveys &c. 27
Canals & Embankments 23

besides having afforded edu=
=cation to numerous young
men who have not been pub=
=licly provided for. It has,
moreover, introduced an ele=
=ment of competition amongst
the Mootsuddi and Sadr
class for which the neighbourhood
of Roorkee is celebrated, which
is likely to be exceedingly
beneficial, not only in the De=
=partment of Public works,
but in all Departments con=
=nected with the general im=
=provement of the Country
in works of Public utility.—

With reference to the
subject of this Chapter there=
=fore, it will be seen that the
System of education now in
force at Roorkee, is likely to be
of great aid to the Canal
Department in general, and
to all improvements where
Irrigation is concerned; that
we may depend hereafter on
an Institution from whence
we may derive Men of 3

different

different classes to aid us in our progress; and that we shall not be, as heretofore, dependent entirely on our own individual exertions for every step of advance that is made towards improvement.—

There are two points which in closing this Chapter, I may very properly draw attention to; the first is the nomenclature of appointments that now exists in the Canal Department; the 2nd is the position that the Chiefs of Districts are to hold with regard to residence. These are questions which have up to the present time led to much confusion, and from the experience that I have had, appear to me to require remedy I shall, therefore, say a few words on each, taking them in the order of their precedence

1st. The Nomenclature of Appointments.—

Up to the period at which I am now writing the Chief authority in the Canal Department is entitled "Superintendent of Canals "in the North West Provinces, "and Director of the Ganges "Canal works". The former being generally applicable to his control over the different canals in the neighborhood, and the latter specifically addressed to the proceedings in

in carrying out the works of the Ganges Canal —

Under the first head he has under him —

1st The Superintendent of Canals West of the Jumna

2nd The Superintendent of Canals East of the Jumna

3rd The Superintendent of Canals in the Doon —

4th The general Superintendence of the works on the Nudjufgurh Jheel the detail of which is specifically under the Civil authorities at Delhi —

Under the 2nd head he Superintends the whole of the Executive Establishment of the works on the Ganges Canal, with the control of accounts &c &c, the appointment being as I said a — before a specific one; to this there can be no objection, it depends upon the Progress and carrying out of a very extensive board of works.

The confusion that now exists arises from the term "Superintendent of Canals" being applicable to the chief as well as to the Subordinates, they are all Superintendents of Canals, and laying aside the affix as applicable to the particular works upon which each Officer is employed, there is no distinguishing mark to separate one from the other. This impression is not confined to

to the Public, but it is exhibited in the Government General orders, and the Office of the Military Board. My own appointment at this moment stands as follows:

Order — "Fort William 31st March 1818

"No 193 of 1818. Major Proby & Thomas Cautley, of the Regiment of Artillery, who was directed in General order No 23 of the 14th Jany 1818 to officiate, is appointed Director of the Ganges Canal and Superintendent of Canals West of the Jumna, from the date on which Major Baker of Engineers proceeded to Europe on Furlough" —

the expression "Superintendent of "Canals West of the Jumna" having been substituted for "Superintendent "of Canals North West Provinces", the appointment to which I succeeded on Major Bakers departure for Europe.

The Executive Engineers who carry on the works of the Ganges Canal, are assisted by young Officers bearing the designation of Deputy Superintendents. There is no uniformity at present in the nomenclature, a point that might be remedied without much difficulty.

As the Canal Department naturally embraces all works intended for the purpose of Irrigation, I would call the Chief by a name directly allied to the functions of his Office, neither referring especially to canals

canals, Tanks, or works of any specific description. A simple definition of the different grades might be as follows:

Superintendent General of Irrigation North Western Provinces having under him

1st	Superintendent of the	Western Jumna Canals
2	Do	Eastern Jumna Canal
3	Do	Doon Canals
4	Do	Mudjufgunk Sheels
5	Do	Northern District Ganges Canal
6	Do	Upper Centrical Dist. Ganges Canal
7	Do	Lower Centrical Dist. Ganges Canal
8	Do	Terminal District Ganges Canal

each of these Officers having Deputy Superintendents under him, with a lower grade of Sub Assistant Civil Engineers.

My present designation of "Superintendent of Canals N.W.P. "and Director of the Ganges Canal "Works" would merge into that of "Superintendent General of "Irrigation N.W.P." whilst the Executive Chiefs would resolve themselves into Superintendents with their Deputies and Sub assistant Civil Engineers. This would be a simple method of Escaping from the confusion of names and titles that now exist.

2nd

2nd The place of Residence for Executive Chiefs, or Superintendents of Districts

A fixed place of residence or Head Quarters Station in each District over which an Officer presides, is most especially called for. It is advocated by me most particularly on account of the regularity that attends on an Office which although called upon to make periodical moves, is provided with a permanent and fixed place of residence; on account of the efficiency of record and reference that attaches itself to fixed accommodation arranged for the purpose; and for the convenience of all who are connected with the Irrigation of the District, in having a recognized public Office, or Court house, to which they can go to transact business. I would, therefore, in each District of the Ganges Canal, determine on some central or most convenient point, at which a Government building should be erected for the purposes of Office, and for the repository of records; at this place the Superintendent of the District should fix his Head Quarters, and it ought to be made a part of the contract on which he holds the Superintendency that he should reside not only at the Station at which the Public Office is fixed, but in its immediate vicinity. As the accommodation required

required for the Office and records at a Head Quarter Station of this sort is not very extensive it might perhaps with advantage be combined with residence for the Superintendent of the District; an arangement which would determinately settle the Question (on the Dumna Canals at present an undecided as well as uncertain one) as to where the Head Quarters Station was to be fixed. It would secure the proximity of the Office to the presiding Chief and it would place the Superintendents of Districts on a par with those, the recognized responsibility of whose situation has made it desirable that the Officer in charge should have a permanent residence.

The Cost of an Office building built of brick and mortar, that is to say, a permanent structure, sufficient for Office purposes may be estimated at 2000 Rupees, or £200 sterling.

The Cost of a residence of an Officer from whom 50 Rupees a month would be deducted for Public residence, allowing that 10 pr cent is sufficient Interest for capital sunk in its construction, would be equal to 6000 Rupees.

Combining the two buildings under one roof, there would on the above Estimate be

be an available sum of 8000 Rupees to expend on the public accommodation above alluded to; additional outlay on Offices might bring the total cost up to 10000 Rupees for each Office and Residence of Superintendents of Districts. - For this expenditure there would be an immediate return of 600 Rupees per annum in House rent - plus the accommodation for the Office and records.

Cummins

The Ganges canal works would require 4 of these public buildings, the total cost of which would be 40,000 Rs.

The sites of these buildings which I would call 1st Class would be as follows:-

1. Superintendent of Northern District	At Roorkee
2. Superintendent of Saoli or Upper Centrical District	At Saoli
3. Superintendent of Bolundshuhur or Lower Centrical District	On some elevated spot between Bolundshuhur and the Canal
4. Superintendent of Terminal District	On some Elevated spot between Muzufferee and the Terminal Lines

Lord Canning Pass only

The above plan would be a security for permanence of position to the Chiefs of Districts; and it would be economical as well as leading to efficiency, to have the principle carried out in determining fixed posts for the Deputies and Overseers; so that every European Officer attached to a District might be placed on a similar footing.

For

For this purpose agreeably to the Scale described in the early part of this Chapter we should require 11 buildings for Deputies and 20 for Overseers at points which at present can only be roughly determined, but which as Irrigation developed itself might be very satisfactorily fixed by the Superintendent General of Irrigation.

Allowing 10 p.c. interest as the return for Capital expended in House property, and that a monthly deduction for House rent from a Deputy Superintendent of 25 Rupees, and from an Overseer of 8, might be fairly made, the outlay on each residence for the former would be 3000, and for the latter 960 Rupees. The total Sum required being as follows:-

11. 2nd Class Residences for Deputies @ 3000 each 33000
20. 3rd Class residences for Overseers @ 960 each 19200
Total Cos Rupees 52200

In the Northern District Roorkee at the Deputies would reside at which place there would be

2 2nd Class Residences;
5 Overseers. 3rd Class Residences;
1 at Myapoor
1 at Puttri,
1 at Dhunowri,
1 at Roorkee,
1 at Muhmoodpoor,

In the 2nd District there would be

3 2nd Class Residences

2

2. on the Suttiguh Branch,
the position of which would
be fixed hereafter when
the works are completed
1 at Sirdhunna:
4 Overseers 3rd Class Residences
3. on the Suttiguh Branch
1. at some intermediate point
between the Suttiguh Head
and the Bhola Falls
on the Main line of
Canal.—
In the 3rd or Bolundshuhur
District there would be
2. 2nd Class Residences
1 at Bolundshuhur Branch Head
1 at Koel Branch head:
4 Overseers 3rd Class Residences
1 on the Bolundshuhur Branch
the site to be fixed hereafter
1 on the Koel Branch - the site
to be hereafter fixed: the
Head of the Branch at
Gungowli would pro-
-bably be the best position
1 at or near to the Sanni
Khowd Escape, of which
he would have Specific
charge.—
1 at some intermediate point
between the Bolundshuhur
Branch Head and the
Kasimpoor Outlet on
the Main Canal—
In the 4th or Terminal District
there would be
4. 2nd Class Residences
1 at the Nanoon Regulators
1 at some intermediate point
between the Nanoon Head
and the High road be-
-tween Mynpoori and
Etawah—

Etawah.

1 at some intermediate point between the Mynpoori and Etawah Road and the Cawnpoor Terminus

1 at some intermediate point between the Mynpoori and Etawah Road and the Etawah Terminus on the Jumna.

7 Overseers - 3rd class Residences

1 at the Kasimpoor Escape Head of which he would have especial charge.

1 at
1 at
1 at
1 at
1 at
1 at
} 6 at [illegible]

The position of the residences of these men would be determined hereafter.

The advantages of an arrangement similar to that above proposed are manifold. In the first place it would prevent non residence and secure to the Canal works and Irrigation settled supervision; and in the second, it would rid the works of an evil which exists to a great extent on the Jumna Canals, and which is ruinous in its effects to Overseers, and even to Officers if they enter upon it, viz: the building of private residences at detached and favorite spots, and a consequent loss of property, on either a Successor refusing to purchase, or on his being posted to another locality. I consider that by providing the

the whole of the Eur-
-tablishment with pro-
residence (for which it must
be recollected the State would
receive fair interest in house
rent) the Canal Department
would be relieved from one
of its greatest interruptions in
the want of permanence in
the disposition of its European
Subordinates —

Barrow

Section II. Ordinary Repairs

I have in the 1st
Section of this Chapter endeavoured
to give an outline of the Estab-
-lishment (Personel) that may
be required for the maintenance
of the works and Supervising
the Irrigation; I will now
enter upon the Ordinary Re-
-pairs or the probable annual
Cost that will be entailed upon
the Government for keeping the
works in efficient repair. —

In Estimating this
Amount, we must take into
consideration the large masses
of water with which we shall
be called upon to deal, the
great extent of building that
exists in the Khadir tract above
Roorkee, and the general char-
-acter of the Ganges Canal so
different from all works for Irri-
-gation in these Provinces. The
Western Jumna canals the
difficulties of which as regards

Slope

of bed are overcome by a
-ctuous course running along
the natural beds of Rivers, offers
no analogy to that of the pre-
-sent work, We naturally ± &
therefore, look to the Eastern Jumna
Canal, where the numerous
Dams opposed to Mountain
Torents, and the multitude
of Masonry Falls or descents
to overcome the natural slope
of the country, present although
in a comparatively small de-
-gree, features by which we
may be guided in arriving
at an Estimate of the annual
Expenditure required on the
Ganges Canal Works

There are two ways of
forming a comparison; the
one by placing the total An-
-nual Expenditure in a rate
on linear dimensions; the
other, by bringing the same
outlay to bear on the average
discharge per second in Cubic
feet.

With the above in
view, I shall take the average
cost on the last 6 years in-
-curred in maintaining the
Eastern Jumna Canal, as during
this period, there has been a
good deal of repair to the
Dams and Channels in the
immediate neighborhood
of the Head, and the cost
offers perhaps a fairer com-
-parison than were I to select
periods of the same length,
where the Head works had had
little

Abd. little spent upon them

It appears from the year 1847/48 to the year 1852/53, the mean cost of current expenses on the Eastern Jumna Canal has been as follows:-

Establishment, including European Supervision and all items	37585	12	11
Ordinary Repairs	35416	8	7
Total Annual Cost Cos Rs	72002	5	6

The length of this canal from the Jumna to Delhi is 137 miles 2 fur 186 feet or say 137 Miles. Its mean discharge pr Second may be estimated during the period above referred to at 800 Cubic feet.-

Now in linear dimension the rate of cost pr Mile on the above data, is as follows:-

Regular Establishment 274:35 Rupees pr Mile
Ordinary Repairs 258:51
Total pr Mile 532:86 Rup.

Assuming the discharge pr Second as the basis of rate of expenditure, we have

Regular Establishment 46·98 pr Cubic foot
Ordinary Repairs 44·27 pr as
Total Cost pr Cubfoot 91·25 Rupees

The length of the Ganges Canal Main Channels is 820 Miles, with a discharge pr Second of 6750 Cubic Feet.

Taking the above rates on the Eastern Jumna Canal as our guide for obtaining the probable cost of the Ganges Canal current expenses; we have in the 1st case where linear dimensions are used

Regular

Regular Establishment	224967·0
Ordinary Repairs	211978·2
Total Current Expenses pr Year	436945·2

In the 2nd where discharge per second is considered

Regular Establishment	217115·0
Ordinary Repairs	298822·5
Total Current Expenses pr Year	515937·5

As the action upon the Channel is dependent entirely on the mass of water with which the works are connected, and as the amount of repairs depends upon this action, we may assume the total as shewn by the latter Table as the most likely to be correct; at any rate that the amount therein stated is likely to be a probable charge for the annual current expenses of the Canal. I would, however, take the mean between the two and as an amount by which in its commencement the repairs and Establishment of the Canal might be limited. I would fix the Sum of 475000 Rupees, of which the details for Regular Establishment and Ordinary Repairs would on the proportion shewn in the Table founded on discharges give to

Regular Establishment	200000
Ordinary Repairs	275000
Total Annual Cost & Co Rs	475000

Burrows

In the early years of progress, we may say for the first

5

little

5 years after water has been admitted, there will probably be many contingent expenses which may call for extraordinary outlay. The large Quantities of River stone that will be required for the Aqueduct flooring and for the repairs of tails of Masonry works in the Khadir; probable strengthening to the protective works on the upper levels of the Raniproor and Puttri Superpassages; excess of dimensions to the Embankments of the Aqueduct on that portion of the line where it passes through the deepest part of the valley, together with additional protective works which may be desirable on the Solani & Rutmoo Rivers both on their up and down stream faces, appear to me to render a further available sum expressly for Khadir purposes very desirable. I would rather anticipate the probabilities of additional cost, and in so doing, point out the places where such may be called for, than leave the chance of such contingencies un-mentioned or unprovided for. I should say therefore, that for the first 5 years after water was admitted an annual sum of 125000 Rupees, in addition to the Amount of Current Expenses estimated for above, should be placed at the disposal of the Director of the works for Contingent

Proposal.

I have thought it necessary to devote a section of this Chapter to the above although I feel that in so doing I am dealing with a subject which must to those acquainted with it, appear to be of a very speculative character: the report, however, would have been imperfect without attention being directed to cost of maintenance; and as the data upon which my figures have been derived, are given; their value will be understood by my successor, whose experience on the works of the Eastern Jumna ~~Canal~~ and this intimate knowledge of the difficulties attendant upon this of the Ganges Canal, will enable him to act accordingly.-

P. 1 rough

I must conclude this report with an offer of my best thanks to those who whether above or below me have so consistently aided the Progress of the Gauges and Works from their Commencement up to the present time.

From those above me, I have met with an indulgence & Consideration for which I can never be too grateful

From those below me, a readiness of assistance & Sympathy under all difficulties that have from first to last been the most cheering part of my service.

Through so many years of progress, & with such a variety of works carried on under circumstances more or less understood the Executive Engineers & Officers in the different Localities have largely aided me with their advice, and recommendations. For these I am greatly indebted. I have endeavored in the above report to place to the credit of every one the merit which appears to be his due; Should I have failed in doing this in any individual instance, I trust that the omission will be pardoned.

To Col Baird Smith who preceded me in the Directorship of the

Ganges Canal works, & to my
excellent friend Mr. Harry
Marten, who from the period of
the early surveys of the Canal up
to the present time, has been constantly
with me, I have to offer my best
thanks. From the first I have to
acknowledge the aid afforded to
me in looking over ~~the Manuscript~~
~~of this report~~, & correcting from the second
undertaking & completing the ar-
rangement of the Plans & Manuscripts
preparatory to their despatch to
England.

To Colonel W. E. Baker of
the Bengal Engineers whose name
appears so often throughout this
report, whose aid I can never
be too thankful for, & whose
friendship has been one of the
bright lights in my Indian
Career, the last words of this
report are dedicated.

Postcript. These Pages cannot be closed without a pressing
lament over the memory of those who have been lost to
us by the events of 1857-58. Captain Edward
Fraser - Capt Frances Whiting, the first shot by his
own men at Meerut, the last most cruelly murdered
in the boats at Cawnpore, Lieutenants Frederick
Angelo - Brownlow - Span all in the prime
of life knocked down by this horrible Mutiny.

London
Sept. 1./62

Pharos

THE
GANGES
CANAL.

M. S.

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Sand of Abingdon

The Ganges Canal

A1

Appendix A. 2 Vols Vol 1

NORTHERN OR 1ST DIVISION

BRICK-MAKING.

This Division whilst the Works were in progress of Construction, includ=ed the first 22½ Miles of the Canal, and + comprehended the whole of the works neces=sary for the passage of the Canal through the Khadir of the Ganges on to the high land of the Doab. From the magnitude of many of these Works, and the impossibility that a sufficient number of Bricks for them could be manufactured by the methods ordinarily in use in India; an account of our + operations in this respect will be pecu=+=liarly interesting, and be the means of placing on record data, which will, perhaps, be valuable to the conductors of future undertakings of an extensive nature.—

The following Abstract gives in one view the several works con=structed, and the Grand Total Cubic content of Masonry for which Material had to be provided; the figures in this abstract are derived partly from the + Bills submitted by the Executive Engineers and

A13

and partly from the Estimates where Bills have not been submitted.-

Works	Cubic Content in Feet.-
Regulating Works, Ghats, Revetments &c. at the Head of the Canal.	520,101
Bridges at Kunkhul, Sowallapoor, Peeran Kulleur & Gunesh poor	567,540
Falls at Bahadoorabad, Nos 2 and 3 and Rs Sol Anuggur, No 5,	1,275,153
Locks at Do. Do. Do. for Navigation	285,061
Superpassages at the Ranipoor and Rutto Torrents, including the Nos 1 and 4 Falls, Locks &c connected with them.	3,250,237
Dhunowri Works for the passage of the Rutmoo Torrent, including the Cross and Regulating Bridges	1,421,668
Solani Aqueduct Works, including the Terminal Bridges at Mahewur and Roorkee.	10992,778
Mills at Hurdwar, Kunkhul and Bahadoorabad.	301,443
Outlet at Kunkhul.	
Inlets at the Lounda Leni walla, Kunkhul Sowalapoor, Selimpoor and Badshahpoor.	173,934
Workshops and Model Rooms.	953,625
Buildings for the accommodation of Establishments, Offices &c.	125000
Grand Total Masonry	19866,540

From a further Abstract it is found that of this mass of Masonry, the following Quantity is composed of Brick.-

Pukka Brick - Solid Masonry	1714871/4
——— Do ——— in casing Kunkhul Betow, and Bonds to Boulder & Slag Masonry	
Total Pukka Brick Masonry	1714871/4
Peela Brick Masonry	542375

And if we add to these the Pukka and Peela Brick

Brick masonry contained in the Civil Engineers College Buildings, the Tuhseel Kutcheri, the Station Church, Buzaars, Road Bridges, and the private dwellings of the subordinates at-tached to the Division; for the whole of which Bricks were supplied from the Government manufactories; we obtain an approximation to the Total Quantity of Masonry for which the Brick manufactories had to furnish Bricks -

	Peela Brick Masonry	Pukka Brick Masonry
	Cubic Feet	Cubic Feet
For Ganges Canal Works	52375	17,148,714
" Civil Engineers College Buildings, Church, Buzaars &c	629,200	419,441
" Private Dwellings	390,000	75,000
Totals	1,561,575	17,643,155

and this is, moreover, independent of an immense quantity of Broken Brick which was used in ballasting the lines of Railway - forming Roads, &c, &c, The Content of which cannot be esti-=mated

From the condensed abstract at the end of this paper, it will be seen that the actual number of Bricks manufactured for the construction of the Masonry above exhibited has been: -

Pukka Bricks of all sizes	1807.79.512
Peela Do Do	307.1112.988
Grand Total number of Bricks	2115.2112.530

Work in Brick making was com-=menced in this Division in January 1852 under the management of Mr Thomas Wright, an

an uncovenanted Assistant in the Canal De-
=partment. Our Object at that period was to
establish as many Kilns as possible at every
available Village in the vicinity of the line
to be taken up for the Canal, and these Kilns
were to be of the ordinary pattern of "Puzawa"
(vide plan Sheet No 1) in constant use with the
natives of India. For the working Season
of 1841/42, Mr Wright reported that he had
obtained Contractors for the manufacture of
Bricks to the extent of 57½ Lakhs, and had com-
=menced on a Small Scale, a few Kilns independ-
=ently of Contractors, the principal portion of the
Fuel used in which, was wood obtained from
the neighboring Jungles. On the 1st March 1843,
the Executive Control of the Division was assumed
by Lieutenant R Strachey, of the Bengal Engineers,
and at an early period, he reported that for the
season of 1842/43, 53 Kilns were in progress of
burning under Contractors. For the Season of
1843/44, Contracts were made for 133½ Lakhs, and
for the season of 1844/45, the Contracts in existence
amounted to 145 Lakhs. For the season of
1841/42, Mr Wrights' contract rates were Rs 350/-
for Pukka Bricks 12"×6"×2; and Rs 200/- for
Peela Bricks of the same dimensions. Lieut
Strachey considering that a thickness of 2
inches was too little for the length of the brick,
made all his Contracts for 2½ Inch at Rs 435/-
per Lakh for Pukka and Rs 250/- for Peela
Bricks, only such Peela Bricks being paid
for at this rate as were taken for use on the
Works.

During the last mentioned work-
=ing Season (1844/45) Lieut Strachey per-
=ceived that the total outturn of Pukka
Bricks had been quite incommensurate
with the advances of money that had been
made, and he determined not to enter into
further Contracts until the accounts of the
existing

existing Contractors had been cleared off: this, however, as will be seen hereafter, was never accomplished. At the latter end of 1845 Lieut. Strachey was called away on field Ser=vice with the Army of the Sutlej, and on his return, the state of his health obliged him to proceed to the Hills on Medical Cer=tificate; his place being filled by Lieutenant Henry Yule of the Bengal Engineers.—

The final results of Mr Wrights and Lieutenant Strachey's operations from January 1842 to June 1846 in Brick making were as follows:—

Advances made to Contractors	79,666	13	1
Expended on Department Kilns	1869	13	6
Carting to Works (portion of Manufactured Bricks only)	5343	6	9
Stacking	761	6	8
Establishment and Sundries..	2937	12	11
Total Amount of Expenditure Cos Rs:	90,579	4	11

The return in Bricks for the above Expenditure was:

Description	2 Inch	2½ Inch
Pukka Bricks carted to Works	22,76,250	8,29,921
Do at Kilns	8,00,000	64,00,000
Total Pukka Bricks	30,76,250	72,29,921
Peela Bricks used in works or Sold	Both dimensions	13,78,235
Do at Kilns	Do.	37,50,000
Total Peela Bricks		51,28,235
Grand Total of all Sorts		154,34,406,

and the actual cost of the Bricks was, therefore,

Pukka Bricks	12"×6"×2	at the Kilns	Cos Rs	550 per Lakh
Do	Do	" Works	"	710 Do.
Do	12"×6"×2½"	" Kilns	"	775 Do.
Do	Do	" Works	"	1000 Do.
Peela Bricks	Average		"	236 Do.

which for Pukka Bricks is considerably in excess of the rates at which Contracts had been entered into.— The Department Kilns upon which Cos

Rupees

Rupees 1869..13..6 had been expended, were entire failures, and this being known to Lieut Strachey as soon as he joined, he discontinued the experiment.- Setting this amount aside, and confining ourselves to the Contractors accounts, we find that.

The Advances to Contractors, were, Cos Rs				79666	13 1
Value of Bricks at the Contract rates					
3076250 Pukka 12"x6"x2"	@ 350/- p Lakh	10766	14 .		
1192295 Pcela Do	@ 200/- pr "	2384	9 5		
722992 1 Pukka 12"x6"x2½	@ 435/- pr "	3 1450	2 6		
3935940 Pcela Do	@ 250/- pr "	9839	13 7		
Real Value of Bricks Cos Rs				57441	7 6
Loss by Contractors Cos: Rs:				22225	5 7

With One exception, the Contractors against whom Balances existed, were men of Straw; every effort was made to get them to fulfil their engagements, or to refund, but all failed: and it was determined by Major Baker, the Director at that time, that Legal proceedings instituted against them, could lead to no other result than the addition of a large amount for Law expenses to the heavy losses which had already been sustained.-

The failures on the part of most of the Contractors were undoubtedly due to the following causes..

1st The impracticability of obtaining from the Villages situated within the small circle to which our operations were necessarily confined, a sufficient quantity of the requisite fuel, with which to burn the large number of Bricks moulded.-

2nd To neglect on the part of the Contractors and their habit of stinting the Kilns in Fuel unless constantly watched

3rd To the want of intelligent European supervision:- for a long time Lieut Strachey had no Overseers, and when he did get them they were unac-

-quainted

=quainted with the work.

1846 and 1846-47.

From June 1846 to the end of the work=ing season of 1846/47, the Brick making Opera=tions were carried on under the Superintendence of Lieut Yule. The little success that attended Lieut Stracheys arrangements for Contract bricks rendered it imperatively necessary that we should depend for our chief supply of this material on our own kilns burned with wood fuel. The measures adopted for this purpose, and the progress made during this period, are thus described by Major Baker in his final report on the Ganges Canal works, dated 11th January 1848.

["A small commencement of the arrangements for this purpose was made in 1846, after the close of the Sutlej Campaign, but it was then too late in the season to obtain any satisfactory results. In the Cold weather of 1846/47 a number of new kilns were built both at Roorkee and Muhewar, and considerable quantities of firewood were cut in the forests and carted to the works. During the early part of the season many circumstances combined to render the result of these operations very unsatisfactory. Great pains had been taken to ascertain the method of burning bricks with wood, as practised at Umballa and elsewhere; but our people did not at first get into the way of loading the kilns properly; and this, combined with a long duration of unfavorable weather, and the green=ness of the firewood, rendered the operations of the Cold weather almost entirely unprofitable. At the commencement of the hot season, however, a change for the better be=came apparent: Two new descriptions of Kiln were tried with better success - and before the setting in of the rains, we had turned out about 38 Lakhs of Serviceable Bricks from the

the English kilns".-

The first description of English kiln tried at Roorkee was that used with considerable success by Major Napier at Umballa: it failed however, with us; and this may be attributed to three causes

1st. Using Dhâk wood instead of Bubool, or other hard woods.-

2nd. Using Koora instead of the light Chuppur Grass employed at Umballa to equalize the surface of the layers of wood.-

3d. Ignorance of the proper management of the fire by means of the flues and the surface covering of ashes.

The second method attempted was that described in the 6th part (Vol: III) of Weale's Quarterly papers on Civil Engineering as that practised in Holland. It entirely failed; the consumption of wood was greater than in the first experiment, and the result more unsatisfactory.-

The third experiment was made with a Flame kiln such as is used in England with faggots: a few good bricks were obtained by this method, but not in a proportion that would warrant a second trial.-

The fourth method was introduced by a Pilgrim passing through Roorkee, who offered to take service as a Brickmaker. His plan was somewhat similar to Major Napier's, and he understood its management; the produce of his kilns were comparatively good.-

The fifth method was taught us by men obtained from Benares; it was less certain than the 4th method, and more dependent on the quality of the wood, but the bricks were less broken and of better quality.-

A more detailed account of the manner of working the kilns above alluded to, will be given when Mr Tinn's operations are under discussion

Sixteen kilns of the above patterns

as.

as also the small flame kiln, were built by Lieut Yule, and he established 3 Hindostani kilns under the supervision of Government servants.. The first fifteen fillings of the English kilns turned out unmitigated failures, the whole of the Bricks being Peela.. The whole number of Kutcha Bricks moulded was 67½ Lakhs; of which there were:—

Loaded in English Kilns	Lakhs	49·8
Do Flame Kilns	"	1·5
Do Hindostani Kilns	"	4·5
Expended in building Kilns	"	9·0
Waste by Rain, &c.,	"	2·7
Total, Lakhs		67·5

and the Total Out-turn from them was

Pukka Bricks	Lakhs	38
Peela Do	"	11
Saiwar	about Cubic Feet	50,000

The Cost of these, including construction of Kilns, clearance of ground, opening out of Roads, and all the implements requisite in this sort of work, was,

Company's Rupees 05638.. 7.. 9¾

which gives the following rates for the manufactured material

Pukka Bricks 12"×6"×2½"	at works Cos Rs	15¼	per Lakh
Peela do Do	at works "	4·50	Do
Do do Do	at kilns "	2·50	Do

The Cost of turning out Moulded and dried Bricks was approximately Cos: Rs: 7559- and consequently the Cost of Kutcha Bricks, was

Company's Rupees 112 per Lakh

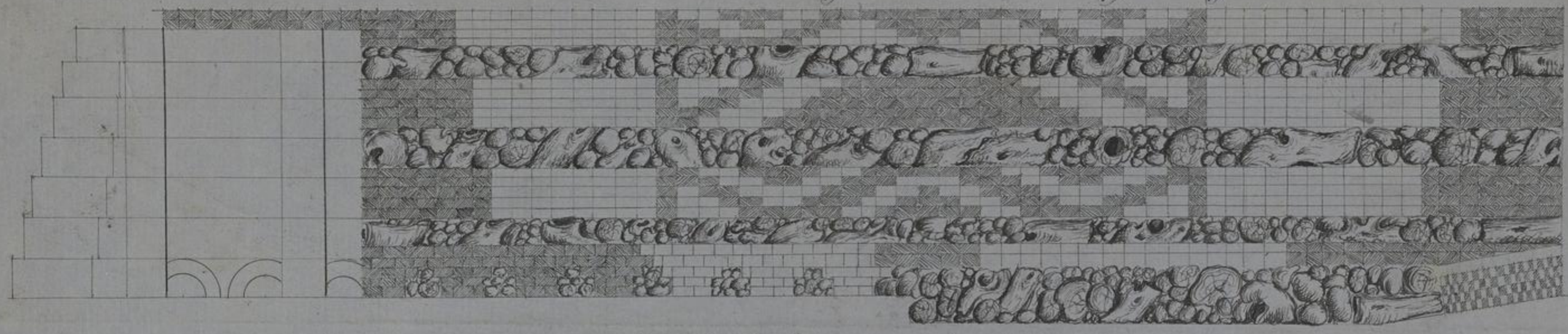
Besides the 49·8 Lakhs shewn above to have been placed in the English kilns, there were 13·6 Lakhs of Peela Bricks reburned in these Kilns- making a Total of 63¼ Lakhs, from which were derived only 31 Lakhs of Pukka

Pukka Bricks, or less than one half of the whole number. The results of the Hindostani kilns were good, being 3½ Lakhs of Pukka Bricks out of the 4½ Lakhs piled into Kilns, and had it been possible to burn them entirely with litter and oopla, instead of the more expensive & article of wood, which had to be put in to make up the deficiency, they would have been cheap Bricks.

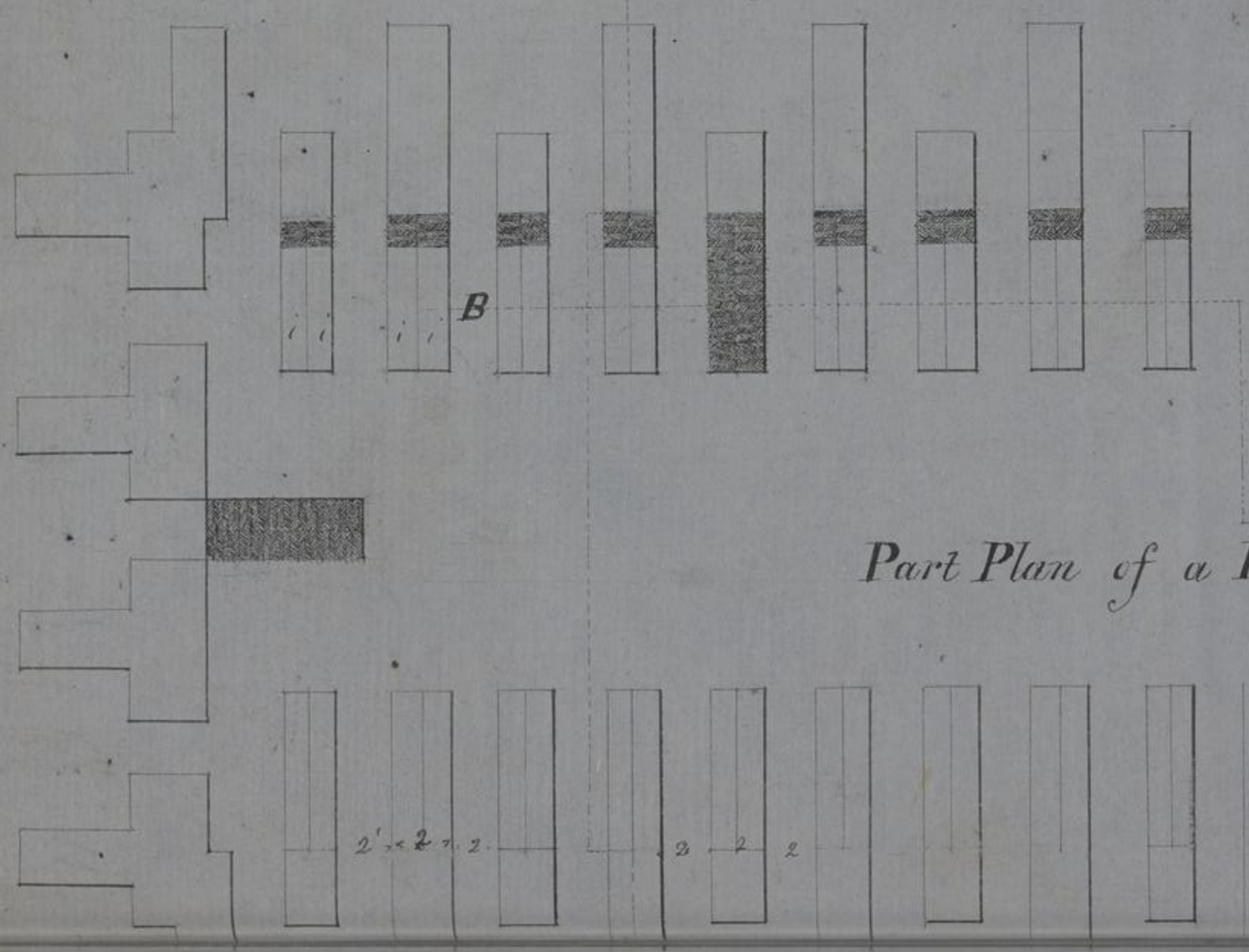
The Operations during the season of 1847/48 carried on under Lieut Yule, should be looked upon as the commencement of a series of experiments the cost of which, though great in itself, was comparatively small with regard to the future expenditure; and in closing the summary of progress up to this period, it is but the just due of the Officers who had been engaged on the works, that I should repeat the concluding remarks contained in Major Baker's report when making over to me the Directorship of the Canal in January 1848, viz:

"The Executive Officers have had to "struggle with many difficulties the con= "=quest of which, though it has smoothed the "path of their successors, has doubtless en= "=hanced the cost of their own work; and "it is important to bear this in mind, and "to be cautious in drawing unfavorable com= "=parisons between the cost of past and future "work - and in attributing to the superior "care and management of future Executives "an improvement in economy which may "be chiefly due to the results of their "Predecessors labors. The power requisite "to maintain the regular and equable "motion of a vast machine, is no "measure of the force required to set "it going."

Part Elevation and Longitudinal Section of a Pilgrim Kiln



A Longitudinal Section on the Line B A



Part Plan of a Pilgrim Kiln

Dimensions of Kiln

72' × 40' × 15'

Sheet N^{o} 2.

Sketch
of a

PILGRIM KILN

Transverse Section of a Pilgrim Kiln

Section on the Line AB
Scale of 1/2 Feet an Inch

Copied by DeWaRens 2 July 1853

The commencement of the working season of 1847/48, formed an entirely new era in the Works on the Ganges Canal. The Government had by this time been moved to sanction their vigorous prosecution, and all the former restrictions as to the amount to be expended annually were taken off. The Works alone in this Division were considered amply sufficient for the supervision of the Executive Engineer; and a separate Officer was appointed for the manufacture and supply of material. Mr Finn entered upon the latter duties in October 1847. —

There were several evils that existed in the arrangements made by Lieut Yule with regard to the relative situations of the moulding grounds, Sughars, and kilns, but as work had commenced actively under the Executive Engineer, and the call for bricks was very urgent, there was not time in the first instance, to rectify them; Mr Finn, therefore, began with the Fields and kilns as left by Lieut Yule and made the improvements so much needed gradually: before the close of the season, Lieut Yule's kilns were almost entirely superseded by new ones, built more substantially, and situated in closer proximity to the drying grounds. The operations were conducted with variable success, and always at a heavy expense; Nevertheless, the turn out of pukka Bricks was highly satisfactory, as compared with the results of former years, and a method of burning was hit upon which seemed to promise well for the ensuing season. Two Hindustani kilns were established on the Roorkee fields under the Supervision of the Government Establishment and were very successfully worked; and several other kilns of this description were set in progress either by Contract, or by hired

hired labor supervised by Government Servants, at villages within a reasonable distance from the works, where the appropriate fuel was obtainable.

The different systems pursued by Mr Finn may be described thus: The description being a precis of that Officers' reports

2 Whites divided

1ST OR "PILGRIM MODE," Vide "Plan and Sections" (Sheet No: 2.)

This mode takes its name from the Pilgrim referred to in the account of Lieut Yule's operations. The floor of this kiln is hollowed out to a depth of 1'. 6" in the centre, with side slopes up to the level of the mouth of the flues; the flues are at 2 feet intervals, 2 feet in width, 2 feet in height, and are carried 5 feet inwards from every side of the kiln; at that distance they cease, and the whole interior is packed with wood to the top level of the flues; two courses of bricks are then laid on edge, and over that the wood and bricks in alternate layers.

The results of the kilns filled on this system were uncertain; the average return was 5½ percent of pukka on the kutcha Bricks piled, but the greater number of the former were broken; the bottom layer, and the bricks in a space of 5 feet all round the walls of the kiln, were always pucka - and Danur was invariably found in the centre. Great damage was done to the walls of the kiln by the heavy pressure of the bricks against them, in sinking as the wood was consumed.

After trials, this system was abandoned, as there appeared little hope of success.

The Quantity of Firewood used per Lakh of Bricks was 3300 Maunds.

IIND OR "BENARES MODE" Vide "Plan and Section" (Sheet No. 3.)

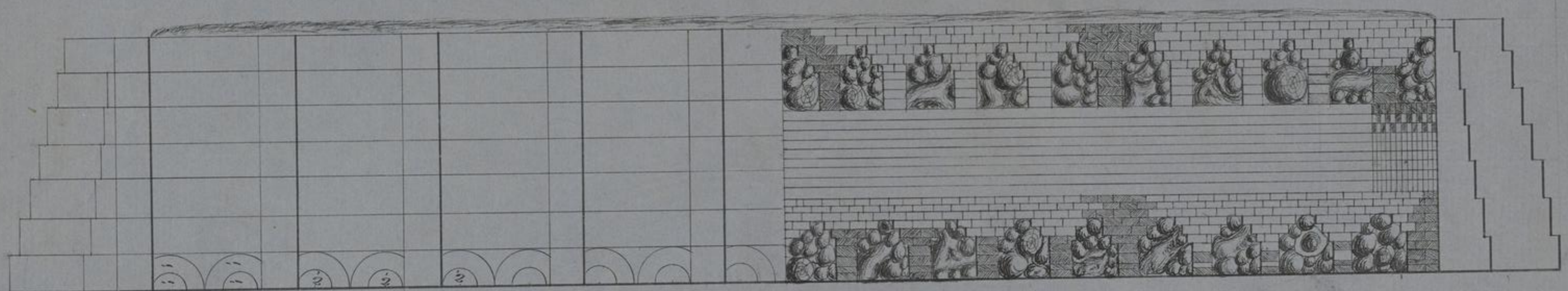
The floor of the kiln is first levelled off, and the bricks are then stacked in tiers of

arches

BENARES STYLE

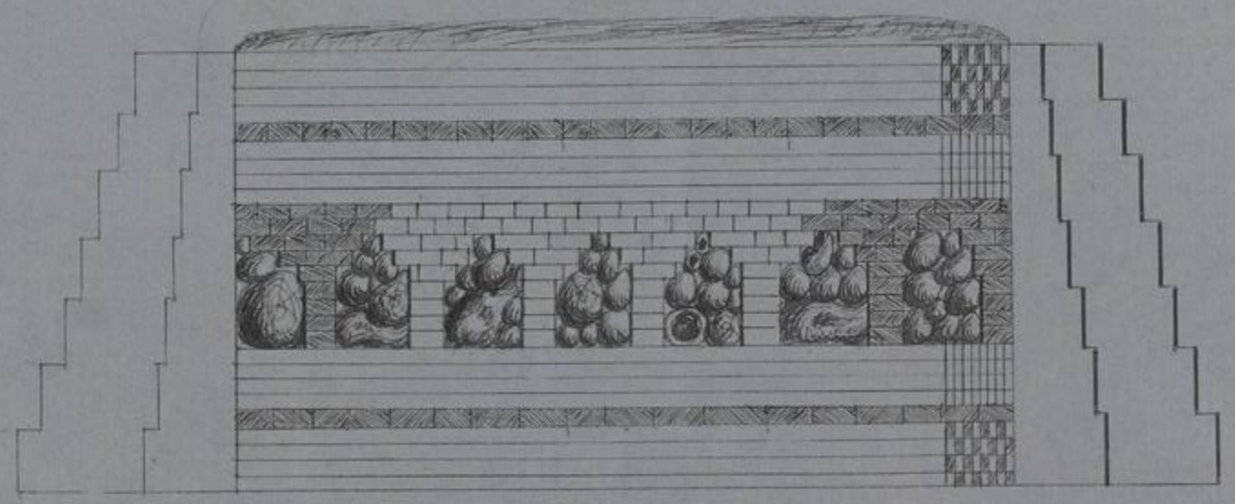
Half Section

Half Elevation



Section on the Line B B

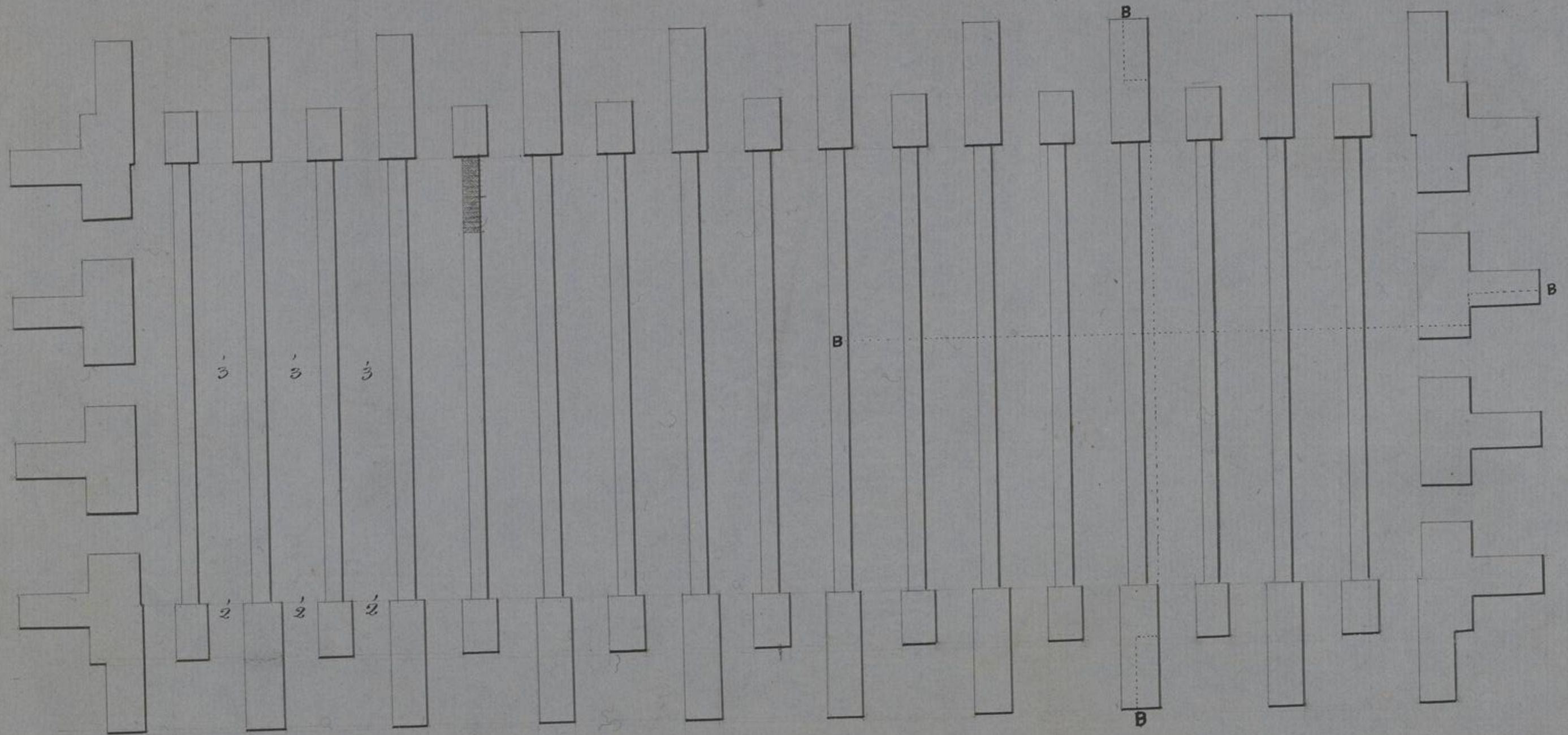
Section on the Line B B



Scale of 7½ Feet to an Inch

Appendix No 2
Sheet No 3

PLAN



Scale 7½ Feet to an Inch

Copied by Mooshtaq Ahmud
6th July 1853

Appendix A

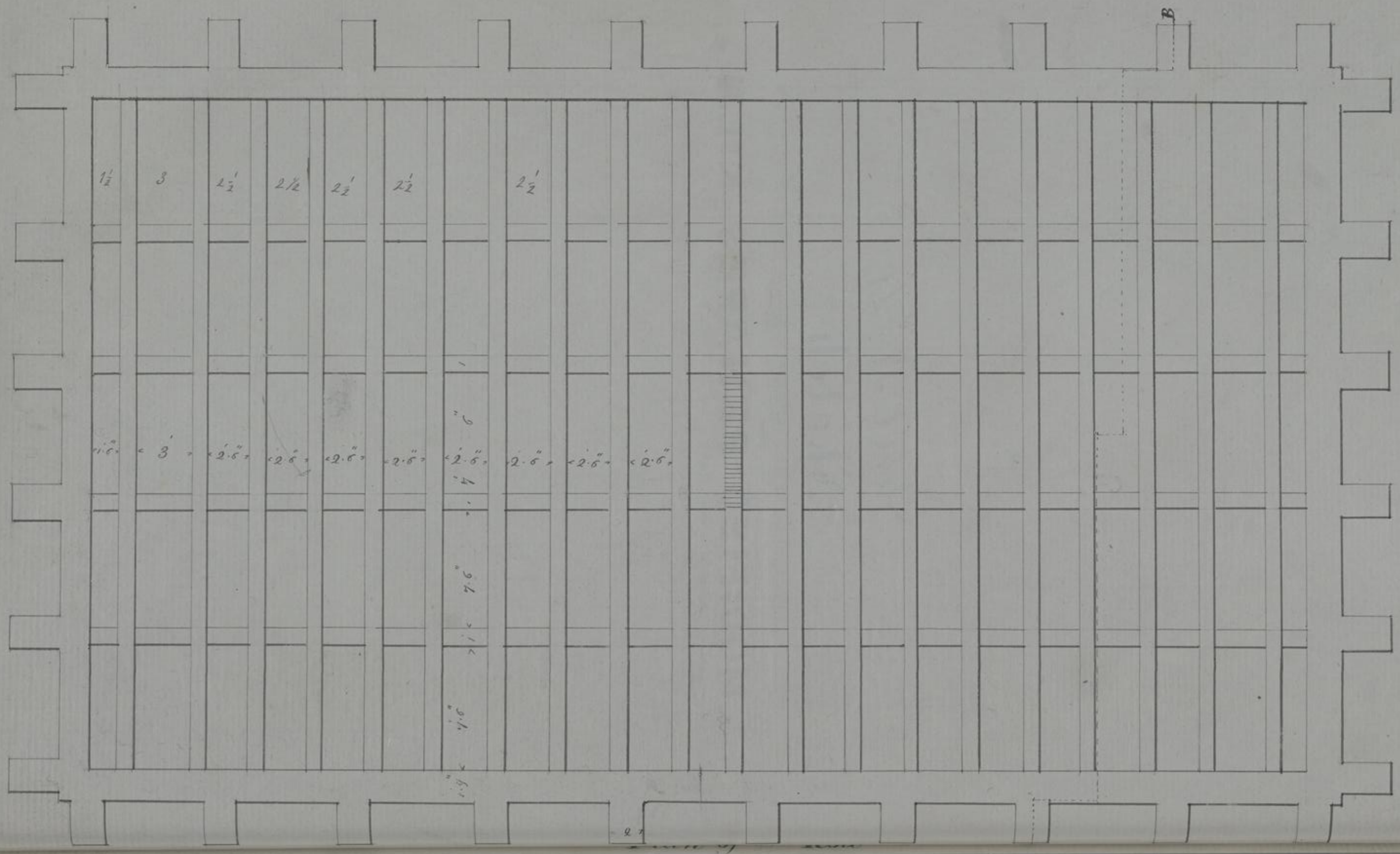
Sheet No. 4

Sketch

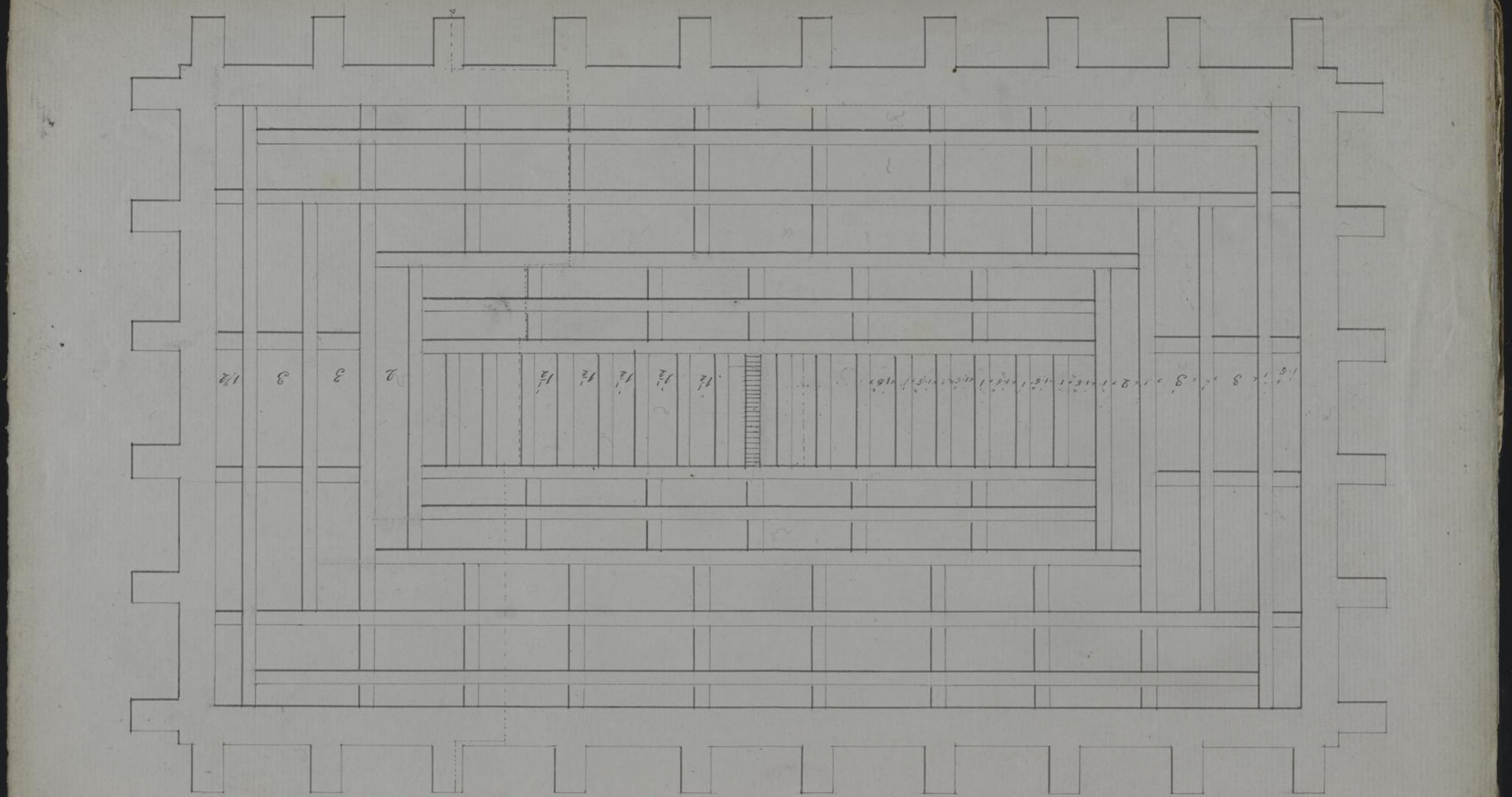
of the

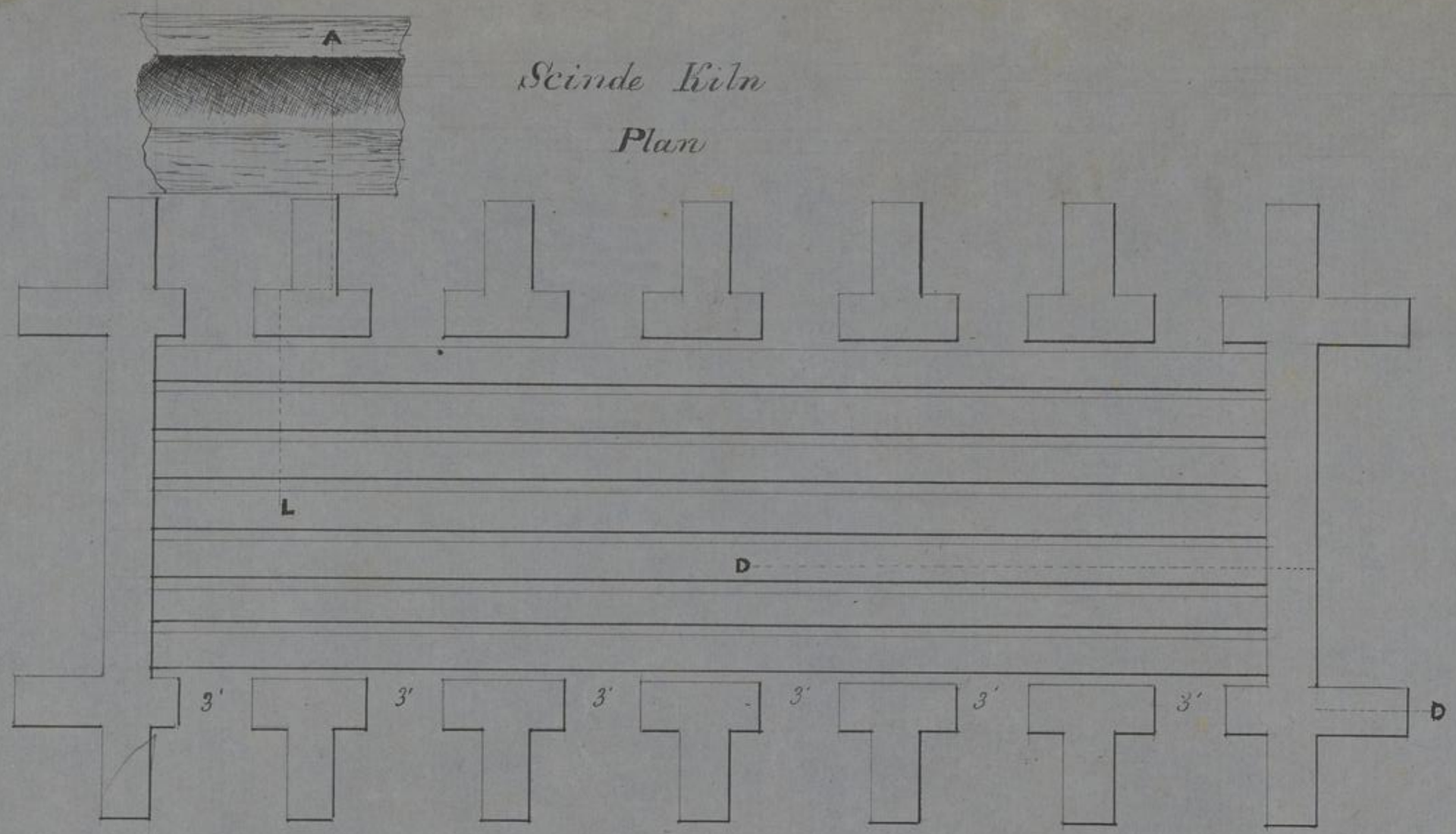
MODIFIED BENARES KILN

Plan of 3rd Row


B
1½
3
2½
2½
2½
2½
2½
1'-6"
3'
2'-6"
2'-6"
2'-6"
2'-6"
2'-6"
2'-6"
2'-6"
2'-6"
1'-6"
1'-6"
1

Empfangen Januar 1855


1/2
3
3
2
1/2
1/2
1/



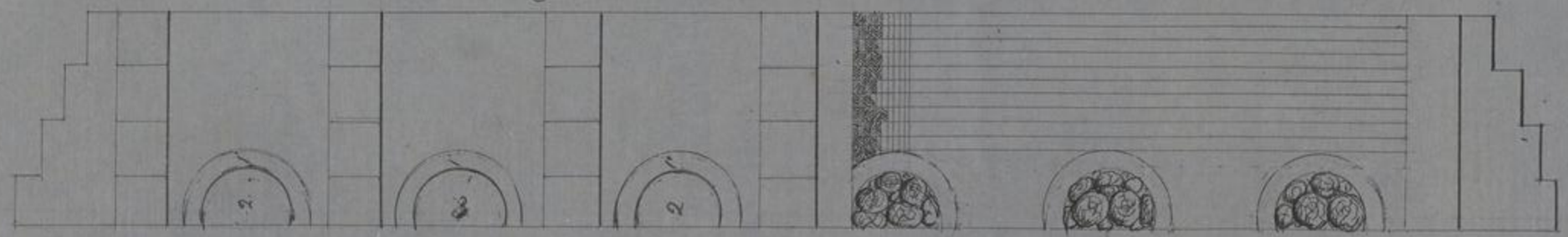
Scinde Kiln

Plan

4th Rem

1/4 Sh

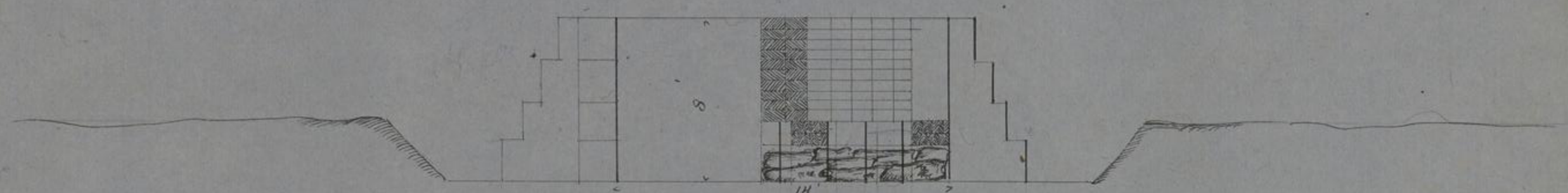
Longitudinal Section and Elevation



Section on the Line D D

Section on the Line D D

Transverse Section



Section on the Line **A L**

Sheet N^o :5

Sketch
of a
SCINDE FLAME KILN

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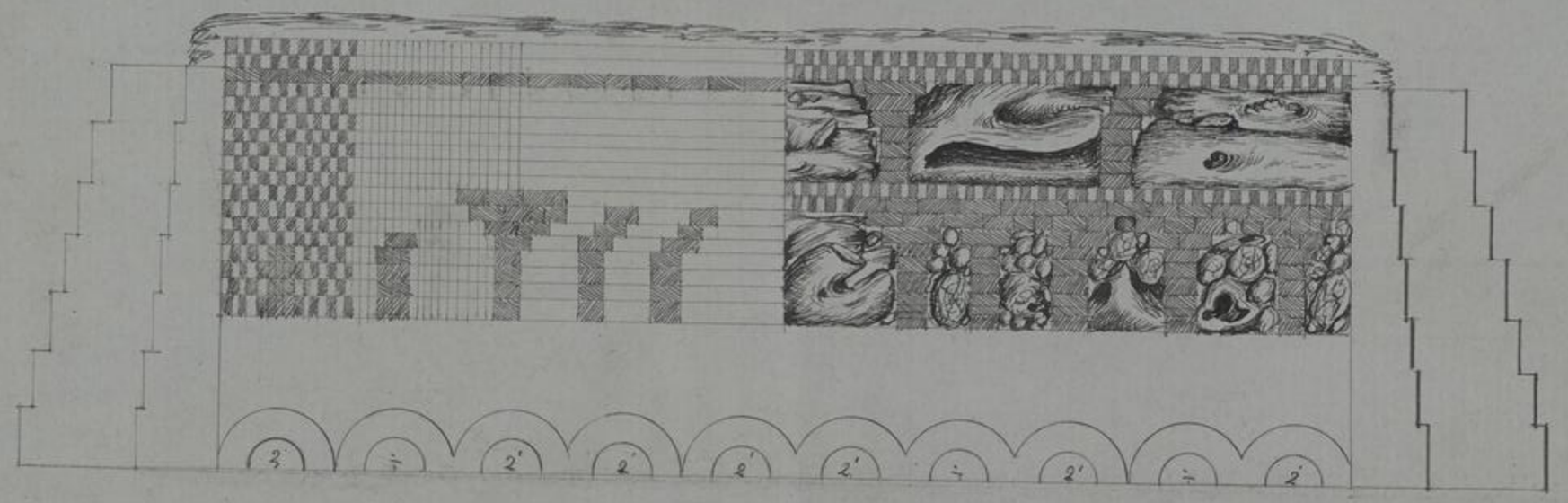
Transverse Section of 2nd and 3rd Rows



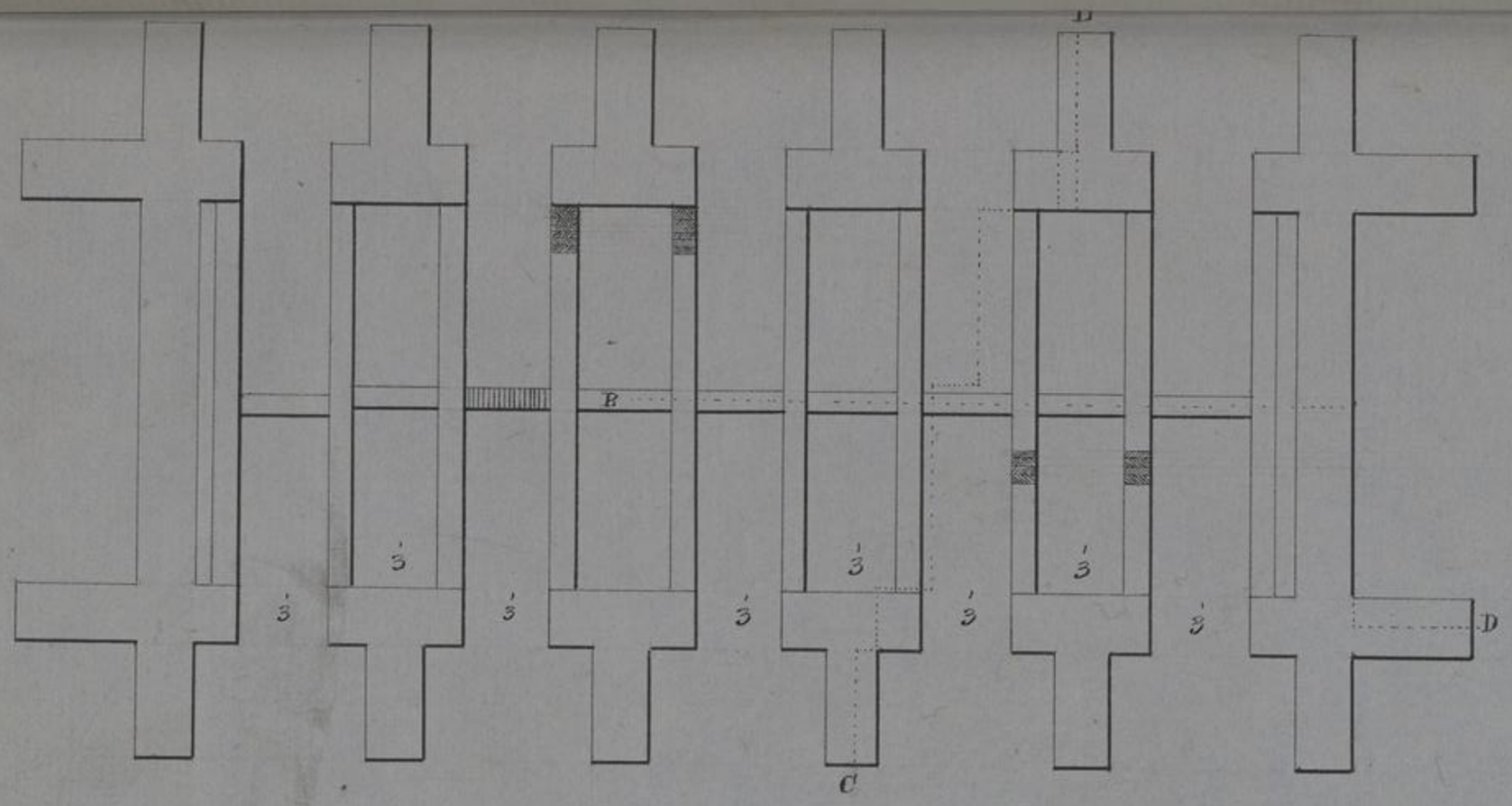
full size

2nd Row - Section on the Line **C L**

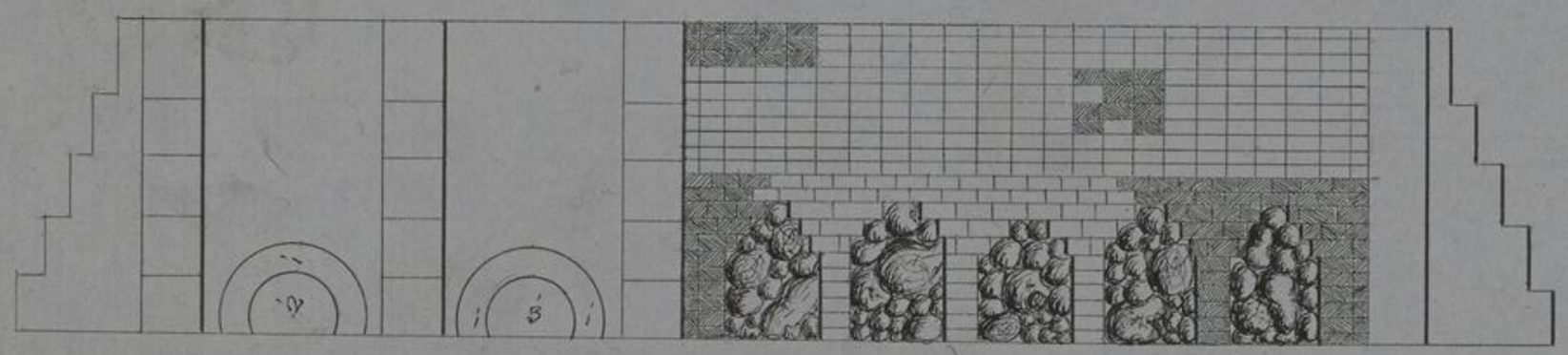
3rd Row *to* **C B**

Sheet No. 6

Sketch of a ROORKEE FLAME KILN

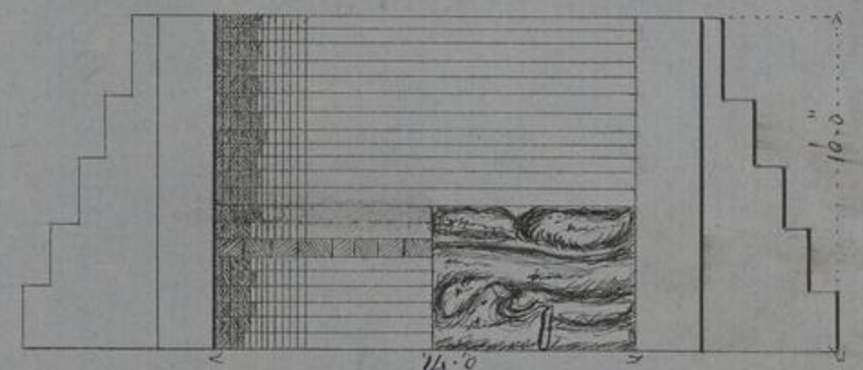


Part Elevation and Part Longitudinal Section of a Flame



Section on the Line BD

Transverse Section of a Flame Kiln



Section on the Line CL

Copied by Mooshtaq Ahmud
8th July 1853

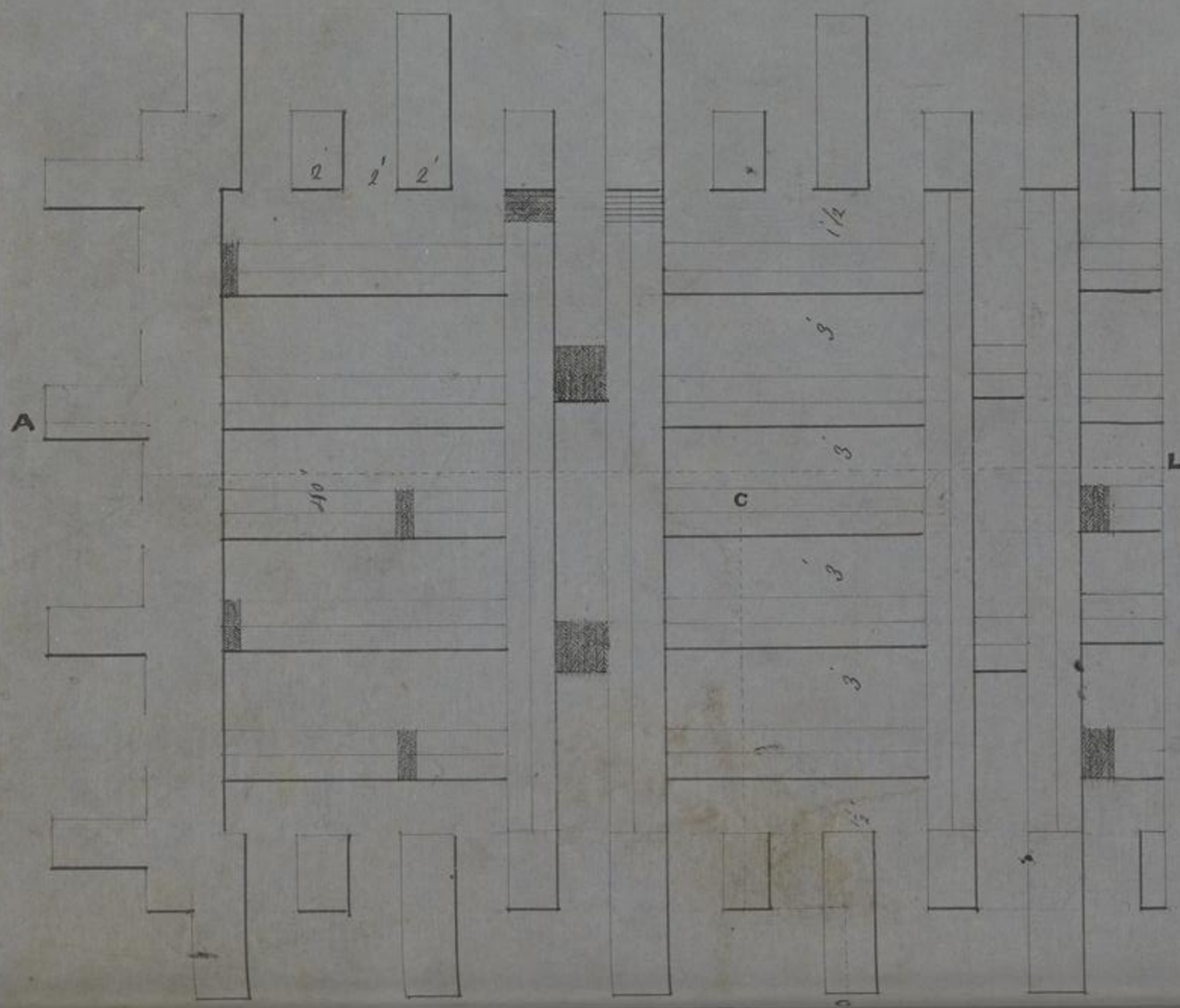
Scale 7½ Feet to an Inch

Sheet No 7

Sketch
of a
LOODIANA KILN

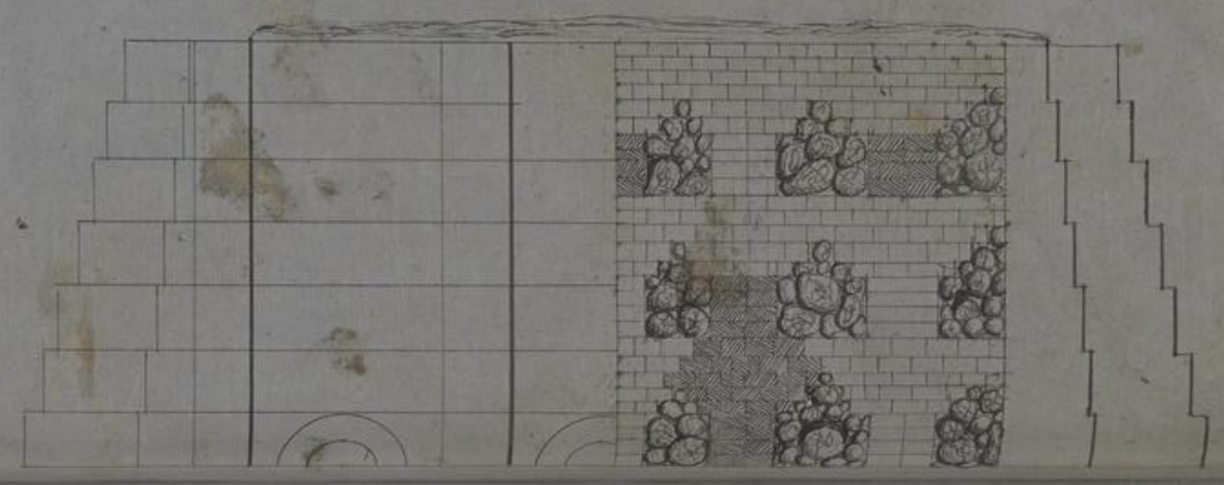
Half Elevation Half Section of Newkiln with 2 Bricks thick

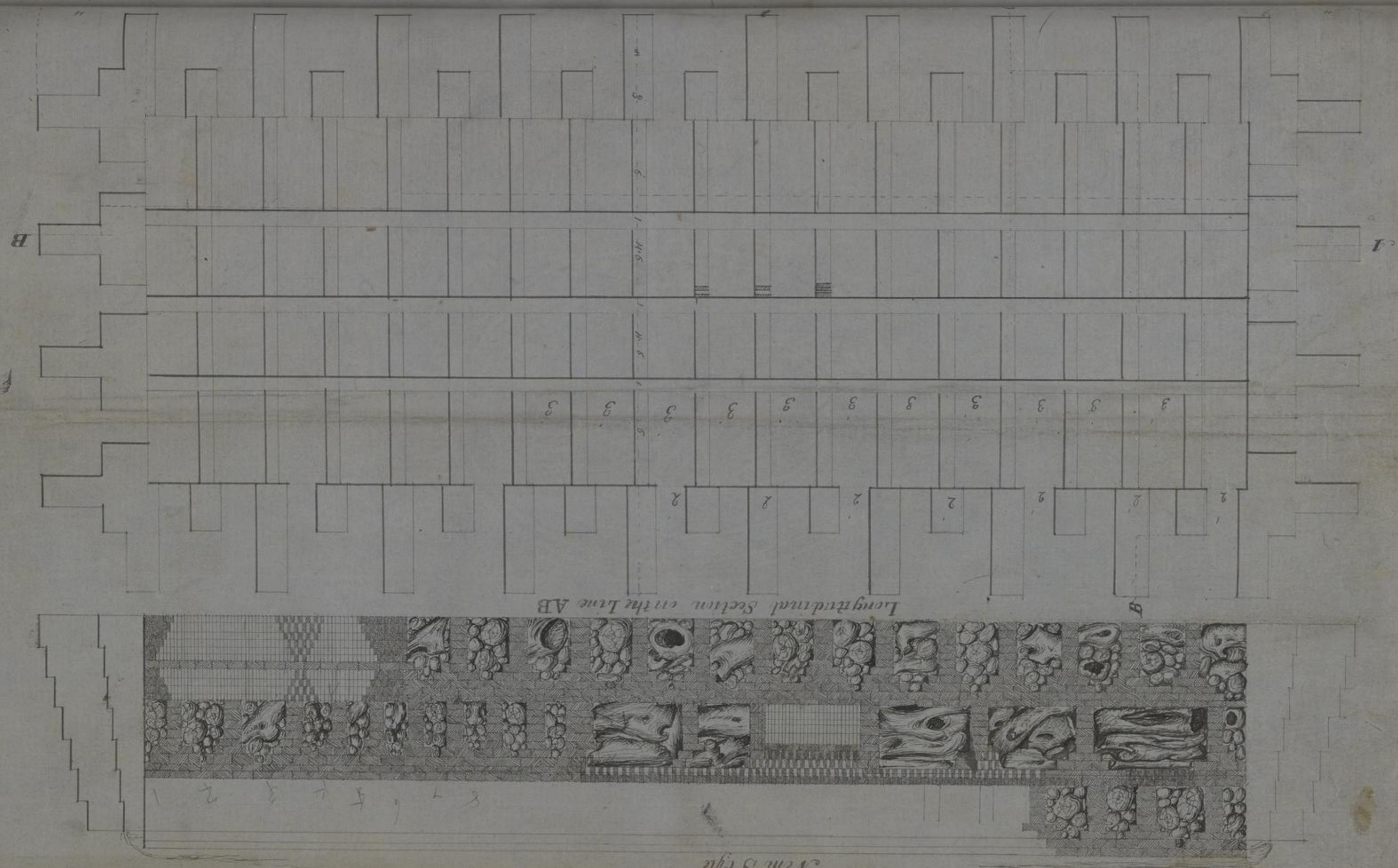
Section on the Line AL



Dimensions of Kiln
72' × 40' × 15'

Half Transverse Section



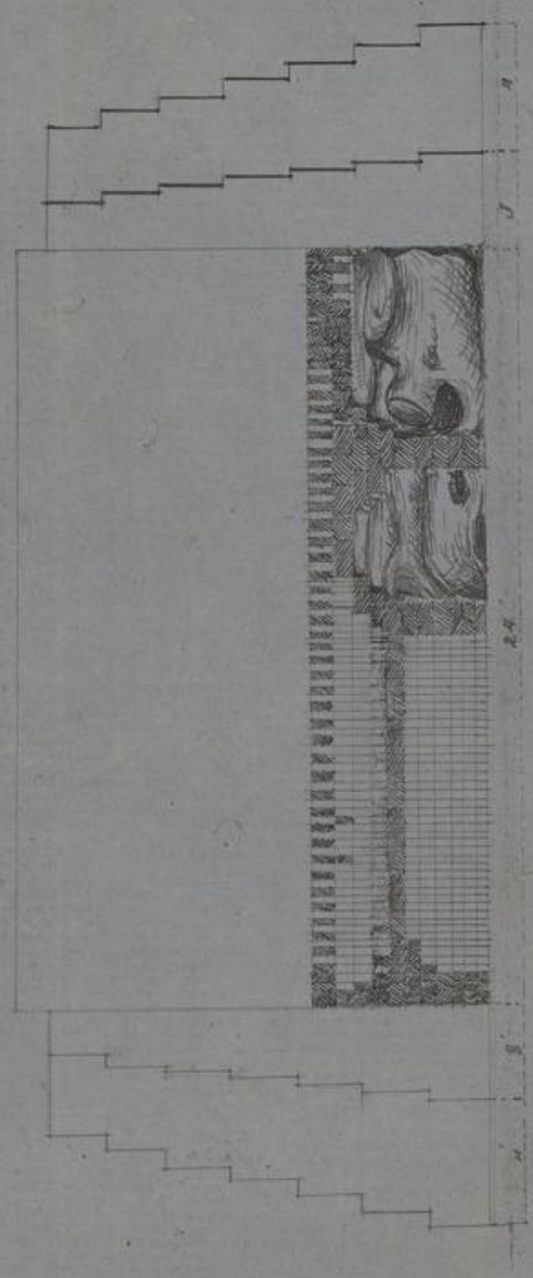

A
B
1
2
3
Longitudinal Section on the Line AB
View Side

Appendix a

Sheet No: 8

Sketch
of
ROORKEE NEW SYSTEM
KILN

Copied by William Jarvis 1863



arched flues throughout the Kiln; the flues are all 3 feet wide at bottom, the piers are 1 foot, or one brick only, in width, and 4 bricks high, from whence the arched is commenced and closed with the 10th tier, making the flues 5 feet high.- When the lower tier of flues is completed, a second tier is built thereupon, crossing it transversely; on the 2nd is built a third tier which completes the Kiln. The wood is carefully packed into each flue as it is constructed, and all interstices filled in with Chips. The average result of Kilns so filled was 55 prbent of Pukka on the Kutcha Bricks piled. The bricks of the lower tier flues, and many in the shoulders of the arches turned out pela, whilst in the centre of the Kiln large quantities of Ganur were found; owing partly to the want of proper distribution of the wood, and partly to the breaking in of the flues, which drawing the fire to particular parts caused vitrefaction.-

The Quantity of Fire wood used per Lakh of Bricks was 3200 Maunds.-

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III^RD^ SYSTEM Vide "Plan and Section". Sheet No 4.-

This was an endeavor made to improve upon the Benares mode: The lower part of the Kiln was packed with a tier of flues similar to the Benares method, and completed with alternate layers of wood and bricks, the lower layer being always less than the upper one in depth or thickness. In some of the Kilns 2 feet of wood, and a layer of 5 Bricks in depth was placed immediately over the flues:- in others, 2 feet of wood and 4 bricks were tried, and over this to form the second layer, 2 feet of wood, and 5, 6, and even 7 Bricks in depth were placed.- The average result of this mode was 55 prbent of Pukka Bricks. The lower portions and sides of the Kiln were bad, turning out pela and much broken bricks; the lower centre produced

Ghama

Damor, whilst the upper centre and the entire upper layer were very good.- Damage was done to the walls of the kiln in the same way as to those of the "Pilgrim" kilns.

The Quantity of wood used per Lakh of Bricks was 3300 Maunds.-

---

Fourth

IV TH: OR, "SCINDE FLAME KILN", "Side Plan", &c. (Sheet No 5.)

An experimental kiln on this plan was built - its interior dimensions being 20' × 12', and it was sunk 3 feet into the ground;- the exterior walls were raised 3 feet high, by 1'. 9"; the two side walls were perforated by three arched flues: each 3 feet wide, 2 feet high, and the centres of each arch were 5 feet apart; these flues were carried across through lines of longitudinal walls built in the interior of the kiln - each wall being 3 feet high, 1'. 6" wide, and about 6 inches apart; it was completed by raising the exterior walls to a height of 8 feet, the additional 5 feet being only 1'. 6" wide, which left a shoulder, 3 inches in breadth, on a level with the longitudinal walls for the bricks of the lower line to rest on.- The kiln was filled by laying the bricks on edge on the top of the interior walls, the flues having been first packed with wood; the first four layers were placed openly, the bricks of the lowest one about 2 inches, and those of the 4th about 1 inch asunder, the remaining 6 layers required to complete the kiln, were packed closely - The kiln contained 7800 Bricks, and was loaded 3 times with the following results

1st	Result	56 per cent
2nd	Do	71 per do
3rd	Do	38 per do (with large well bricks 3 inches thick)

On each occasion it was fired vigorously for 60 Hours:- when the fire reached the 2nd line of Bricks from the Top, the kiln was covered in by

by a layer of ashes 3 or 4 inches thick.

The Quantity of wood used to each kiln was 350 maunds, or about 4500 maunds to each Lakh of Kutcha Bricks.-

The advantages in these kilns were, that they were more readily packed than the larger kilns; and the large proportion of whole bricks obtained from them.- The disadvantages were, the great expenditure of wood, and the injuries sustained by the Arches of the interior longi=tudinal walls by every firing.-

Encouraged by the favorable results of the above described small kilns, Mr Finn tried others on a larger scale, and with the view to economizing the expenditure of wood, and following out the plan of a Scinde kiln with which he had been provided. the centres of the arches or flues were extended from 5 to 8 feet apart, and the interior width of the kiln was made 14 instead of 12 feet. The same process of filling and firing as had been practised in the small kilns were adopted in these, but the results were unfavorable; the out-turn being nothing but 2nd class and pela Bricks: this plan was, therefore, abandoned. The dimensions of the largest Scinde kiln were 150' × 14' × 8'

V^TH^ OR "ROORKEE FLAME KILN." *Vide* Plan &c. (Sheet No 6).

It being supposed that the last described kiln failed on account of the flues being so far apart, and the advantages of burning by flame being evident: Mr Finn determined to try a modification of the Scinde pattern. For this purpose he removed the interior longi=itudinal walls from the large kiln above mentioned, and increased the height of the interior walls by 2 feet - making the kiln 150' × 14' × 10'. Its floor was levelled off and a tier of arched flues 3 feet wide and 5½ feet high was formed from side to side; on the top of these

these flues 8 rows of bricks on edge were piled, the four under layers being rather open, the upper layers close.. Every other flue only had an arch, small holes being left in the piers for the fire to communicate; each of the open flues were divided by a cross wall one foot thick to prevent the wind blowing the fire through the bottom of the kiln.-

The average result from 6 kilns burned during the season was 70 per Cent; and the expenditure of wood was about 4½00 Maunds to each Lakh of Kutcha Bricks.-

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VI TH OR, "LOODIANA SYSTEM," *Vide* Plan, &c. (Sheet No: 7.)

Introduced by a native, who professed to have gained great experience in brick burning under a European Soldier at Loodiana. It's System differed from that of the Benares one, in having 2 bricks in the piers of the flues instead of one, and in having one flue open and three closed, instead of firing from the whole. The two kilns filled by this man were great failures, and his system was at once abandoned.-

---

VII TH OR, ROORKEE NEW SYSTEM, *Vide* Plans, &c. (Sheet No: 8)

The kilns previously described having been filled time after time without any marked improvement in the out-turn of Pukka Bricks, it became necessary to find out a mode by which better and more regular results would be ensured. The Benares System was, therefore, modified in the following manner.-

Instead of one uniform width & height of flue, the "Roorkee new System" kilns had them of various sizes according as experience had taught that they were required. Thus, in the lower part of the kiln where Pela bricks prevailed in the Benares, the new System had flues 3 feet wide and 5'. 6" high. The arch commencing on the

6 ins

6th instead of on the 4th brick, which gave space for a considerable quantity more fuel. In the centre of the 2nd tier where Danwr formed, the flues were reduced to 1½ feet in width, and on each side of these were placed 2 two feet flues, the tier being completed with 2½ and 3 feet flues towards the sides and ends of the Kiln, where in the Benares System Pela Bricks were found; the arches of the 2nd tier of flues commenced on the 5th brick throughout, and were 10 Bricks or 5 feet in height. In the 3rd tier, one, and half flues were made at each end of the Kiln, 3 feet, and all the rest were 2½ feet wide; the arches commencing on the same brick, and being of the same height as in the 2nd tier. The flues of each tier were divided by cross walls into cells of about 10 feet in length, and this was found to be a great improvement, by increasing the number of Bricks in the Kiln, and, consequently, decreasing the quantity of fuel; and by regulating in some measure the current of wind and air through the Kiln.

The superiority of Kilns filled in the manner just described was soon apparent: a comparison between 8 English Kilns filled on previous plans, and 8 of the same size filled in the new way gave, for the former, an average return from each Kiln of 35737 whole Pukka Bricks, or 55·4 per cent; whilst the latter gave 61140 whole Pukka Bricks and an average percentage of 66·3: shewing an increase of 11 per cent of Pukka Bricks with the very great advantage of nearly twice the number of whole ones. This method was, therefore, continued throughout the remainder of the season - and the best Kiln yielded a percentage of 87·6 of pukka bucks on the Kutcha ones piled into Kiln. The quantity of wood used in these Kilns was about 3000 maunds per Lakh of Kutcha Bricks.

~~White lime~~

In

In all the English kilns filled by Mr Finn 2 layers of broken bricks were laid flat on the top, and over these kiln ash was deposited in ridges at first, and spread out when the fire made its appearance at the top of the kiln. the layer of ashes being from 9 to 12 inches in depth. In firing, the flues were replenished with wood for from 36 to 48 hours after lighting, or until the fire had laid good hold of the kiln. Various methods of firing were tried; some with every other flue closed; some with one open and two closed; and others with one open and 3 closed flues. The system of 1 open and 2 closed appeared to act the best, as the fire passed more equably through the kiln than in the others. Two flues were attended and fired by 1 Beldar, and the kilns were watched day and night for a week after firing, and all the chasms and sinkings filled up with Ganor.—

The wood with which these kilns were fired was Dhâk, Peepul, Burghut, Saul, Jeu but the most part was Dhak derived from the Kheree Forests; it was cut by Servant Beldars and carted in by Contractors at a rate of 9 Rupees per 100 Maunds. 800 Carts were constantly employed on this work alone during the Season under review.—

The Two Government Hindostani kilns yielded a return of 83¼ per cent. which was an excellent result; but the bricks were dear, for this system of burning, owing to the scarcity of the description of fuel (Khat and Koora) required, some of which had to be carted in from Villages distant about 6 Miles, and the carriage of fuel alone for the first kiln cost the Sum of Rs 6.4.3. Oopla, which on the Jumna Canals was obtained at 2 Rs cost at Roorkee Rs 6.. 8.. 0 per 100 maunds.

The Hindostani kilns established in neighboring villages were also successful, having contributed to the Grand Total out turn for the season 26,50,200 pukka bricks.—

In

In the early part of this season the Kutcha Bricks were moulded upon the bare ground, and were of very bad shape - leading not only to failures in burning by the in=-compact way in which they piled into Kiln, which admitting passages for air, flame and heat - caused the fire to be rapidly expended without doing its proper duty; but also to ex=-tra expense in the Masonry built from them, by the amount of Chipping and dressing which they required before being laid in the work.. To remedy this, Pukka terraces, or Masonry platforms with even surfaces, were introduced on all the Brickfields upon which the bricks were moulded, and in a short time our bricks were equal to the best table moulded bricks that could be turned out.. Up to the 31st July, however, the cost of the Kutcha bricks was very high - having been Rs 1 1 1 per Lakh. The detail of this expenditure is introduced here, in order that comparison may be made with similar detail for future years, when the improvements made in the relative situations of the Jughars and & moulding terraces had reduced the price of Kutcha Bricks to a fair average rate. -

1 Brick moulder @ 7 Rs per month	7	..	..
3 Beldars excavating and carrying earth to the Jughars, a distance of about 300 feet @ 4 Rs per month	12	..	..
1 Beldar breaking clods and rough tempering the mould	4	..	..
3 Beldars mixing and carrying the clay to the Moulder @ 4 Rs per Month	12	..	..
1/16th of a Bildar for ashes & water @ 4 Rs per "	..	10	8
1/24th of a Bullock drawing water - say	1	12	..
Establishment	..	8	..
Sundries Expense of Bamboo hand-barrows - Handies and Koondahs - wear and tear of Kutcha Chunnasses and well ropes; repairing brick moulds, Stacking the bricks, and occasionally covering them with Grass Chuppers to protect them from the rain	1	..	..
Total Company's Rupees	38	14	8

(9-C.)

Each moulder and his attendants, as per above account, cost per Month Rs 38.. 14.. 8, and each on an average turned out 1000 Bricks per diem, a per Month 31,000
Deduct for 4 Sundays in a Month 4,000
Balance, the number of Bricks made by 1 Moulder 27000

Then if 27000 Kutcha Bricks 12"×6"×2½" cost Cos Rs 38..14..8, One Lakh will cost Cos Rs 143..15..9

It must be understood that in shewing the results of each seasons operations, a period extending from about the middle of October to the end of the Month of June following is embraced. In the Statements which are given below all the work done in the Government fields during the season is represented; the Bricks from the Outlying Hindostani kilns are never available until after the season in which they were piled into kiln has passed - hence, therefore, the 21050200 Pukka Bricks stated in a former paragraph to have been derived from Hindostani kilns are not included in the returns, but are brought to account in the abstracts for the ensuing season.

The results of the season of 1847/48 may be described thus:-

Kutcha Bricks moulded		207,79,187
Piled into Kilns	164,99,652	
Used in building kilns &c	8,35,000	
Loss by Rain - wastage, &c,	25,73,623	
Stock remaining at close of Season.	8,70,912	
		207,79,187

The return from the kilns so filled, was

Pukka Bricks of all sizes	108,91,961	or 66 per cent	on the Kutcha Bricks filled into kilns
Peela — Do — Do	54,56,933	33 do	
Shama — Cubic Feet	1,19,615	1 do	

The total cost of the seasons operations, was

Company's Rupees 168,072..12..5

and, after deducting from this the value of the few Bricks made for the special purposes of pillars, Architraves, &c; and excluding altogether 32,55,285 Peela Bricks which, as not being at the time required for the works, were held to be of no value, the following rates were exhibited for the Bricks in ordinary use.-

Pukka Bricks 12"..6"..2½" at the kilns Cos Rs.	1154	5	9	per Lakh
Peela — Do — Do — Do — " —	250	"	"	— Do —
Shama — Do — " —	2	"	"	per 100 Cubic Feet

Sheet N°: 9

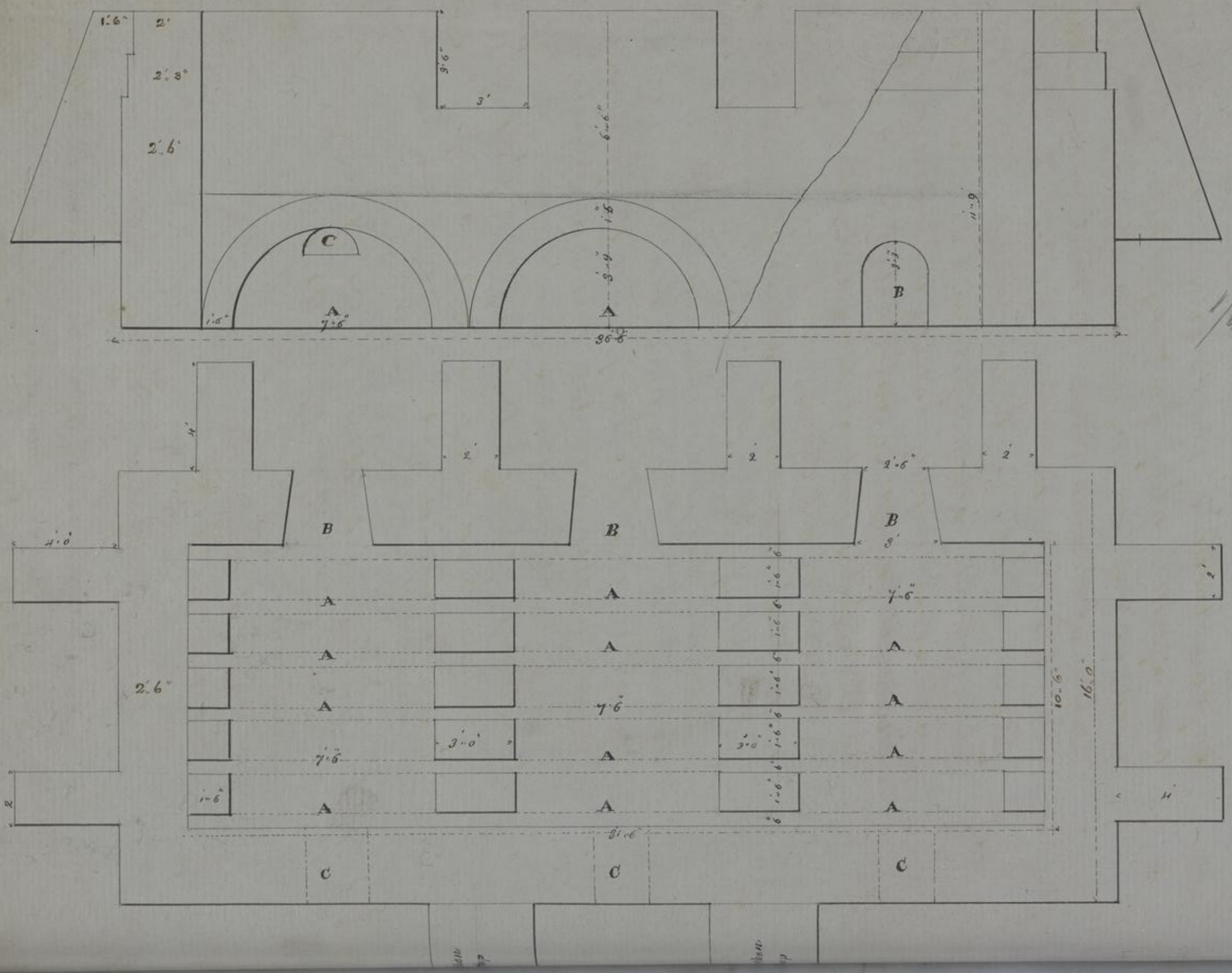
PLAN
of
FLAME KILN

Reference

A Interior Vaults
B Exterior Flues for Firing Kilns
C Draft Openinges in rear of Kiln not used at Roorkee

Appendix a

1/4



Scale of 5 feet to an Inch

White book

1848-49

The results of the season of 1847/48 had so fully proved the success of the "Roorkee Flame" and "Roorkee new system" Kilns over all others that had been tried, that the Brick burning of 1848/49 was for some time confined to these two modes, and Mr Finn's operations were carried on steadily; the out-turn of Pukka Bricks increased in number, and each Quarters accounts exhibited a reduction in their cost. - In February 1849, Captain Weller of the Engineers visited Roorkee and spoke highly of a Flame kiln which he had used in Scinde. As we had already learnt the value of Flame kilns - in their easy manage-ment, and freedom from broken bricks, his plan was at once tried. - The few first trials were not very successful, but in a short time, with some modifications introduced by Mr: Finn, it proved so satisfactory and regular in its results, that it was introduced to the exclusion of all others, not only in the Roorkee and Muhewar fields which were remodelled for the purpose, but in the new fields which were now being established at Dhunowri and Selimpoor. - Plan and Sections of this Kiln are given in Sheet No 9. and the following Memorandum on the method of filling and firing it, which was submitted by Mr Finn on the 1st March 1850 - after a full years ex-perience had established its complete success. will be found of the greatest value -

"Memorandum on the Filling and Firing of Flame Kilns. -

"Interior dimensions of Flame kiln in general use "at Roorkee Vizt.

Length	31' .. 6"	
Breadth	11 .. 0	Above flues
Height	6 .. 6	— Do —

Excavate to a depth of 3 feet for the floors or bottom of the kiln, giving any foundation below that depth, local circumstances

circumstances may require; Slope away the ground in front of firing flues so as to give the Firemen ready access to them.

A Kiln is loaded in	1 day
Fired in	2 days
Cooled in	4 days
Emptied in	1 day
Total	8 days

A Kiln of the above given dimensions contains about 15500 Kutcha Bricks, each brick being 12" × 6" × 2½".

24 Beldars Load a Kiln

18 Do unload a Do ; These men also select the Bricks into Classes - First, Second, and Peela -

The Quantity of Dry wood expended at Roorkee in firing a kiln 48 hours is 575 Maunds; and the number of Beldars (Firemen) employed to feed the Flues 24; Thus, 2 Men to each Flue - 6 to a Kiln - The Firemen work in Spells of 12 hours night and day; Then for 48 hours firing, 4 Spells, and 6 Men for each = 24 Men

No Ashes or Covering of any sort to be placed on the top of the Bricks in the Kiln; and when the firing of the Kiln is completed, the flues should not be closed up, but left open -

Bricks and wood are placed separately in Flame kilns, the former are packed on top of the inner longitudinal walls 12 bricks or 6 feet high, and the latter is placed in the 3 vaults at the bottom of the kilns. The spaces, 6 inches wide, between the longitudinal walls, are flues for the admission of the heated air upwards. The lower tier of Bricks in Kiln are placed about 2 inches apart, the 2nd, 3rd, 4th and 5th a little closer, and from the 6th to the 12th tier inclusive, the bricks are packed in closely - When the bricks are placed in the Kiln, the vaults are filled with wood and the firing commenced. This operation should be carried on vigorously for at least 24 hours, by which time, if the bricks are baked, the fire will be well up all over the top of the Kiln -

During the cold season, or when bricks are not thoroughly dry on being packed into Kiln, it requires fully 48 hours to bake them -

A Firewood issued to the Roorkee kilns is charged for at the rate of 11 Rupees per 100 maunds; this wood is of various sorts, but by far the greater part of it is Dhāk which is supposed to be about the very worst description that could be had for the purpose - Babool, Khyr and Tamarind are all good, and doubtless

doubtless of either sort, a much less quantity than we expend of Dhāk would suffice to bake a kiln of bricks - but of these we have none here.

("Firing kilns on high windy days should if possible be avoided - for then the bricks require a longer time to bake, and the kilns seldom or never afford a good return; the bricks of the windward side invariably remain unbaked -

("The average return of Pukka from kutcha Bricks baked in the Flame kilns at Roorkee for one month was 81·7 per cent - Some of the kilns however yielded a return of 92·8 per cent."

White

At the commencement of this season (October 1848) Halls brick making Machine (for a description and plans of which, see appendix) was set up at Roorkee - Mr Finn, and the overseer Sergeant Durant, in immediate charge of the Roorkee Brick fields, first made themselves acquainted with the working of the machine, and then taught a party of Bildars the use of it; for the first 3 months, owing probably to the awkwardness of the men employed, it was constantly getting out of order, and considerable interruptions to progress was the consequence; but Mr Finn persevered, and before the close of the season, had the satisfaction of seeing it work regularly, and of counting 11670 Bricks made by it in one day - an Outturn fully equal to the best that had been obtained in England or America - These Bricks from the process the Clay undergoes in its passage through the Pug Mill are beautifully tempered, and when burned are found to be very close grained; their only disadvantage being, that their size 9½" × 4½" × 3" differed from that in common use on the Ganges Canal works They were invariably burned in Hindostani kilns under the Supervision of the Government Establishments -

Before this Machine was in full work, the men employed on the Ganges Canal Brick fields, as moulders, were the most in-

-tractable

=tractable and troublesome class of people that were on the works; their combined and frequent efforts to evade the doing of a fair days work, or to extort higher rates of pay caused much anxiety; Every attempt to coerce a Moulder, or even if fault was found with the quality or quantity of work performed by one or more of them, led to a stuke of the whole body.- When, however, they saw that we could turn out from the Machine 11000 Bricks per day, independently of themselves, they became the most docile of our people, and after a while, they were glad to receive 6 Rupees per Month for a full days work.-

At first it was attempted to work the Machine by Horses, but they were found not to answer so well as bullocks, and 4 of these latter animals were, therefore, employed daily in cutting and Mixing the Clay in the Pug Mill: 2 worked from Sunrise till noon, and the other 2 from 2 P.M. till dusk.-

At the close of the season, the complement of Men attached to the Machine for working was as follows:-

Excavating the Clay and carrying it to the Pug mill Cistern. an average distance of 130 Feet-	11 Beldars
Supplying the Cistern with water and cleaning up the drying ground	2 do
Filling the Pug Mill from the Contents of the Cistern	3 do
Cleaning and handing the moulds preparatory to passing them into the Machine	1 do
Serving the Machine with empty brick moulds	1 do
On the Wheel for pressing the mixed Clay into the moulds	1 do
On the Lever, for forcing out the moulds	1 do
On the Mister, or Strike, cleaning top of the Bricks and raising the moulds to the heads of the Carriers	1 do
Carrying the loaded moulds from the Machine to the drying ground	6 do
Relieving the Carriers of the moulds and placing the Bricks in regular lines on the drying ground	1 do
Total	28 Beldars

The following Abstract of work people employed, number and cost of the Bricks made by

A 13

by this Machine, from its setting up to the ter-
-mination of the season, may well find a
place in this report, as it shews how progres-
-sively Mr Finn increased the turn out of
Bricks, and decreased their cost.

Months	Date	Bullocks @ Rs [illegible] pr month	Do @ 3/8 pr month	Chupprassies @ 8 Rs pr month	Horses @ 5 as pr diem	Bullocks @ 5 as pr diem	Bricks made daily	Remarks	Total Monthly Expenditure, and rate of Bricks manufactured
October 1818	23	7	"	1	2	"	2090	Commenced making Bricks	Labor Rs 15. 12. 10
	24	9	"	1	2	"	2695		Sundries " 10. 11
	25	15	"	1	2	"	2400	Beam of Pug Mill broke	Total Cost Rs 20. 7. 9
	26	2	"	1	"	"	"		Average Cost pr. Lakh
	27	5	"	1	"	"	"	Sunday	Cost Rs 160. 1. 6
	28	5	"	1	"	"	"		
	29	5	"	1	"	"	"		
	30	15	"	1	2	"	3010	Work recommenced	
	31	21	"	1	2	"	2600		
Total		79	"	9	10	"	12795		
November 1818	1	2	18	1	2	"	2290		Labor Cost Rs 103. 1. 4
	2	2	18	1	2	"	2130	The Cistern of the Pug mill broken	Sundries " 5. 3. 9
	4	.	7	1	"	"	"		Total Cost Rs 68. 5. 1
	5	.	7	1	"	"	"	Sunday	Average Cost pr. Lakh Cost Rs 103. 9. 2
	18	.	12	1	"	"	"	Filling the Cistern and Preparing for work	Do — " — 91. 11. 6
	19	.	12	1	"	"	"	Sunday	after deducting wages for Sundays
	20	.	18	1	2	"	4000		
	21	3	18	1	2	"	5790		
	22	5	16	1	2	4	6450		
	23	5	17	1	2	4	6850		
	24	5	23	1	2	4	6240		
	25	5	25	1	2	4	6570		
	26	5	25	1	"	"	"	Sunday	
	27	5	22	1	2	4	6550		
	28	6	22	1	2	4	6880		
	29	6	22	1	2	4	7000		
	30	3	25	1	2	4	5210		
Total		52	307	17	24	32	65960		
December 1818	4	5	24	1	2	4	5080		Labor Rs 18. 9. 3
	9	5	22	1	2	4	4090		Sundries " 0. 0. 0
	10	5	22	1	"	"	"	Sunday	Total Rs 18. 9. 3
	12	5	24	1	2	2	6000	Horses altogether discontinued	Av: pr Lakh Rs 122. 10. 9
Total		20	92	4	6	10	15170		Do after deducting wages for Sundays " 101. 3. 10
January 1819	9	10	"	"	"	"	"	Filling Cistern	Labor Cost Rs 77. 5. 2
	10	3	"	"	"	"	"	Preparing for work	Sundries " 1. 14. 2
	11	28	"	1	"	4	6120		Total Cost Rs 79. 3. 4
	12	28	"	1	"	4	7370		Average Cost pr. Lakh Rs 88. 11. 4
	13	28	"	1	"	4	7500		Do " 74. 4. 9
	14	28	"	1	"	4	"	Sunday	after deducting wages for Sundays
	15	15	"	1	"	2	3050	Machine out of order	
	18	28	"	1	"	2	7000		
	19	25	"	1	"	4	7100		
	20	26	"	1	"	4	7000		
	21	26	"	1	"	"	"	Sunday	
	22	26	"	1	"	4	7000	Machine out of order	
	26	29	"	1	"	4	7100		
	27	29	"	1	"	4	7400		
	28	29	"	1	"	"	"	Sunday	
	29	28	"	1	"	4	7500		
	30	29	"	1	"	4	7650		
	31	29	"	1	"	4	7500		
Total		444	"	16	"	48	89290		

months	Date	Bildars @ 1 Rupee per Months	Bullocks @ 5 Annas per diem	Bricks made Daily	Remarks	Total monthly Expenditure and rates of the Bricks Manufactures
February 1849	1	29	4	7700		Labor Cost Rs 37.10.3
	2	29	4	7150		Sundries " 2.6.3
	3	29	4	8040		Total Cost Rs 40.0.6
	4	29	"	"	Sunday	
	5	29	4	8090		Average Cost per Lakh Cost Rs 88.8.9
	6	29	4	8020		Do ystm 4.79.1.3
	7	3	"	"		deducting wages for Sundays
	8	26	4	6210	Clearing out Pug Mill Machine Broken	
Total		203	24	45210		
March 1849	20	12	"	"	Filling Cistern with Clay and Preparing	Labor Cost Rs 53.10.7
	21	25	4	6200		Sundries " 2.3.8
	22	26	4	8100		Total Cost Rs 55.14.3
	23	26	4	8050		
	24	27	4	8110		Cost per Lakh Cost Rs 64.5.2
	25	27	"	"	Sunday	
	26	27	4	9125		Average Cost per Lakh
	27	27	4	9515		Do
	28	27	4	9540		after deducting wages for Sundays 60.2.8
	29	27	4	9580		
	30	28	4	9000		
	31	28	4	9670		
Total		307	40	86890		
April 1849	1	28	"	"	Sunday	Labor Cost Rs 136.4.9
	2	28	4	10260		Sundries " 9.12.6
	3	28	4	9075		Total Cost Rs 146.1.3
	4	28	4	10050		
	5	28	4	10026		Cost per Lakh Cost Rs 66.12.0
	6	28	4	9960		Do
	7	28	4	10100		after deducting wages for Sundays 58.0.5
	8	28	"	"	Sunday	
	9	28	4	10000		
	10	28	"	"	Holidays on account of Hurdwar Fair, Bildars allowed 1 days pay	
	11	"	"	"		
	12	28	4	9480		
	13	28	4	10180		
	14	28	4	10030		
	15	28	"	"	Sunday	
	16	28	4	10200		
	17	28	4	9600		
	18	28	4	10370		
	19	2	"	"	Cleaning Machine	
	20	28	4	6500		
	21	28	4	10360		
	22	28	"	"	Sunday	
	23	28	4	10650		
	24	28	4	9840		
	25	28	4	10620		
	26	28	4	10450		
	27	28	4	10140		
	28	28	4	10350		
	29	28	"	"	Sunday	
	30	28	4	10100		
Total		786	88	218441		
May 1849	1	28	4	10500		
	2	28	4	10240		
	3	28	4	10500		
	4	28	4	10300		
	5	28	4	10500		
	6	28	"	"	Sunday	
	7	28	4	10640		
	8	28	4	10750		
Carried Over		224	28	73430		

Month	Date	Bullocks @ 4 Rupees per Month	Bullocks @ 5 annas per diem	Bricks made daily	Remarks	Total Monthly Expenditure and rates of the Bricks Manufactured
Brought over		224	28	734430		
May 1849	9	28	4	10520		
	10	28	4	10650		
	11	28	4	10560		
	12	28	4	10700		
	13	28	"	"	Sunday	
	14	28	4	10680		
	15	28	4	10680		
	16	28	4	10450		
	17	28	4	10700		
	18	28	4	10250		
	19	28	4	10550		
	20	28	"	"	Sunday	
	21	28	4	10460		
	22	28	4	10500		
	23	28	4	10900		
	24	28	4	10800		
	25	28	4	10950		
	26	28	4	10900		
	27	28	"	"	Sunday	
	28	28	4	10900		
	29	28	4	10900		
	30	28	4	10950		
	31	28	4	10980		
Total		868	108	287410		Labor Rs 149.12.0 / Sundries 7.9.10 / Total Cost Rs 157.5.10 / Average Cost per Lakh Rs 547.12.2 / Do / after deducting wages for Sundays £ " 149.8.8
June 1849	1	28	4	10900		
	2	28	4	10950		
	3	28	"	"	Sunday	
	4	28	4	10900		
	5	28	4	10980		
	6	28	4	10900		
	7	28	4	10980		
	8	28	4	10980		
	9	28	4	10980		
	10	28	"	"	Sunday	
	11	28	4	10960		
	12	28	4	10900		
	13	28	4	11670		
	14	28	4	11000		
	15	28	4	11300		
	16	28	4	11450		
	17	28	"	"	Sunday	
Total		476	56	154850		Labor Rs 83.3.9 / Sundries " 0.6.0 / Total Cost Rs 83.9.9 / Average Cost per Lakh Rs 53.15.1 / Do / after deducting wages for Sundays " 46.8.1

N.B. Half pay for a Tindal @ 8 Rs per month charged throughout

Total number of Bricks made by this Machine during the whole Season 976616 - at an average Cost of Company's Rupees 68..9..8 per Lakh.

Bricks made by the Machine during the month of May Cost on an Average Cost Rs 57..12..2 per Lakh - and the rate of the Bricks moulded by hand on the Pukka Terraces at Roorkee during the same month was Cost Rs 91..0..10 per Lakh; the pay of the Beldars for Sundays in both cases being

being included; Size of the last mentioned Brick (unburnt) 12½" x 6¼" x 2⅜". During June, 28 Beldars at 4 Rs per Month and 4 Bullocks @ 5 annas each, made with the Machine on an average 11046 Bricks per day; and during the same period to make 11200 Terrace moulded bricks, it required

Moulders @ 6 Rs per Month	4	
Beldars @ 4 " Do	39	
Total	53	Men

Two of Ainslie's Brick making Machines reached the works during this season, but too late to admit of their being fairly tried.

Hindostani Kilns were as usual established at outlying villages, but their out turn not being known at the close of the season, the results are not exhibited in the general returns which follow.

The Average Cost of The Kutcha Bricks made on the Government fields was Cos Rs 119.. 0.. 0 per Lakh, and the following Table represents the details of this rate.—

1 Brick Moulder	@ 6 Rs per month	6	"	"
3 Beldars, Excavating and Carrying Earth to Jughars, breaking Clods and roughtempering the mould	@ 4 Rs per month	12	"	"
2½ Beldars Mixing and Carrying the prepared Earth to the Moulders	@ Rs 4 per month	10	"	"
1/16th of a Beldar for Ashes and water	@ 4 Rs per month	"	10	8
¼ of a Bullock drawing water	Say	1	12	"
Establishment		"	8	"
Sundries - detail as in former Table		1	4	"
Total Company's Rupees		32	2	8

As in the former Table The Cost of 27000 Bricks is here represented Then if 27000 cost Rs 32.. 2.. 8 One Lakh will cost Cos Rs 119.. 0.. 0 nearly

The number of Kutcha Bricks moulded on the Government Fields, was, including those on hand at the close of the previous season			196,23,674
Filled into Kilns	160,64,468		
Used in making and repairing Kilns	8,92,152		
Loss by Rain, Wastage &c	20,13,914		
Stock remaining at close of Season	53,140		196,23,674
The return from those filled into Kilns was:			
Pukka Bricks	110,07,328	or 68·5 p Cent	On the Kutcha Bricks filled into Kilns.
Peela Do	36,08,720	" 22·5 "	
Shama Cubic feet	1,35,876	" 9·0 "	

The produce of the outlying Hindostani kilns was 36,92,829 Pukka Bricks, making the Total results of the season as follows:-

Pukka Bricks		14,700,157
Peela Do		3608720
Ihama	Cubic Feet	135876

The total Cost of the Seasons Operations was

Company's Rupees 14,9219.0.11

giving (under the same conditions as explained in last Season's resumé) the following average rates for the Bricks in ordinary use.

Pukka Bricks 12"x6"x2½" at kilns	Cor Rs	736	2	6	per Lakh
Peela Bricks	Do "	250	"	"	Do
Ihama	"	3	6	6	per 100 Cubic Feet

1849-50.

The Brick making season of 1849/50 commenced at Roorkee and Muhewar in October 1849. The new fields established during this season at Delimpoor and Dhunowri were also in active progress, the former from November 1849, the latter from February 1850. The whole of these Fields were provided with Pukka Terraces for moulding the Kutcha Bricks upon; and the only System employed for burning the Bricks was that of the Flame Kiln. In April 1850, a Brick making Machine on the same plan as Ball's patent, manufactured in the Roorkee Workshops, was set up at Muhewar, and was worked with equal success as that which had been brought by me from England. By the end of the season, but too late for bricks to be made from it, another similar Machine, also manufactured at Roorkee, was established at Dhunowri; and the several brick fields were now in the order in which the whole of the future Operations were carried on.-

Ainslie's Brick making Machine, although every effort was made to render it

of

capa-

of use, proved an entire failure on our Works, and was eventually abandoned.-

Hall's Brick Making Machine continued to keep up its Character; and the Maximum out turn in any One day during the season was 12200.-

The same Course of work was gone through as described for 1848/49. and the results show a considerable improvement.-

The average Cost of the Kutcha Bricks made on the Government Fields was Co.Rs 88-4-3 per Lakh; the detail of this rate is represented in the following Table.-

1 Moulder	@ 6 Rs per Month	6	..	..
1 Bildar, Excavating and carrying Earth to Tughars, breaking Clods, rough tempering &c	@ 4 Rs per Month	4	..	..
2 1/2 Bildars Mixing and carrying the prepared Earth to the Moulders.	@ Rs 4 per Month	10	..	..
1/6th of a Bildar for Ashes and water	@ " 4 per "	..	10	8
1/2 of a Bullock drawing water	say	1	12	..
Establishment		..	6	6
Sundries	Detail as in former Table	1	0	..
Cost of 27000 Bricks — Company's Rupees		23	13	2

Then if 27000 cost Rs 23-13-2 - 1 Lakh will cost ~~Co~~ Rupees 88-4-3.-

The present season exhibits the Kutcha Brick Making in its most favorable aspect, the above rate being the lowest ever arrived at.- Mr Finn's arrangements were now matured. The quantity of work that could be done by each individual employed was known, and the performance of it strictly insisted on, and from this period forward no variation, except in the One item of "Excavating and carrying Earth to Tughars, &c." was permitted:- This item was necessarily a fluctuating One, and it was entirely dependant on the distance the Earth had to be carried.- The Excavations for this Earth were carried on, at Roorkee within a defined Area so that on the close of our Operations a Large Tank or Reservoir might be formed for

for the Convenience of the Town - In April 1854 this Reservoir was 1480 Feet long, average 376 Feet broad, and 12 feet deep. -

The number of Kutcha Bricks moulded on the Government Fields was, including those on hand at the Close of the previous Season;		~~250,13,771~~
Filled into Kilns	186,48,800	
Used in retraining Kilns	23,34,520	
Loss by Rain, Wastage, &c.,	40,30,451	250,13,771

The return from those filled into Kilns was:

Pukka Bricks	147,83,540	79 per cents	On the Kutcha Bricks filled into Kilns.
Peela D.	32,75,200	18 per "	
Thama (Cubic feet)	76,391	3 per "	

The produce of the Hindostani Kilns was 41,50,000 Pukka Bricks, making the Total results of the Season as follows:-

Pukka Bricks	189,33,540
Peela D.	32,75,200
Thama Cubic Feet	76,391

Hall's Brick machine made during this season 15,15,095 Kutcha Bricks; of which 1423195 were piled into Kilns, and 91900 were destroyed by rain.

The Total Cost of the Seasons Operations was,

Company's Rupees 161601.. 8.. 5

Giving (under the Conditions before noted) the following average rates for the Bricks in ordinary use:-

Pukka Bricks	12"x6"x2½"	Cos Rs	752	12	4 per Lakh
Do Do	9½"x4"x3"	"	536	..	.. Do
Peela Do	12"x6"x2½"	"	250	..	" Do
Thama			6	..	" per 100 Cubic feet

About 1500 Carts were constantly employed during this Season in Carting Fire wood to the several Fields.-

Capn -

Rule

1850-51

17-D

The Brickfields having now been established on one fixed principle, and the same course of work being in operation throughout, it will be sufficient to exhibit the results, noting that this season was marked by extraordinary Cold weather rains which led to great loss in Kutcha Bricks, and to much interruption in progress. Nevertheless, the returns exhibit continued improvement, and the seasons operations were highly satisfactory

Hall's Brick Machine made 3,90,670 Kutcha Bricks, of which 32,26,670 were filled into Kiln, and 5,64,000 were destroyed by rain. The maximum number of Bricks made by this machine in any one day was, in the present season, 12500.

Kutcha Bricks moulded on the Terraces of the Government Fields Cost Company's Rupees 96..9..9 per Lakh

The number of Kutcha Bricks moulded on the Government Fields was:—		309,52,045
Filled into Kilns	221,21,100	
Used in repairing Kilns &c	30,86,115	
Destroyed by Rain &c	57,44830.	309,52,045

The return from those filled into kiln was

Pukka Bricks	189,42,100	85 b/m/cub	On the Kutcha Bricks filled into Kilns.
Peela — Do	25,57,800	11¼ "	
Thama (cubic Feet)	66546	3· "	

The produce of the Hindostani kilns was 75,00,000 of Pukka Bricks, making the total results of the season as follows:—

Pukka Bricks	264,42,100
Peela — Do	25,57,800
Thama (cubic Feet)	66546

The

The Total Cost of the Seasons operations was Company's Rupees 219586..5..9

Giving (under the conditions before explained) the following Average rates for the Bricks in Ordinary use:-

Pukka Bricks	12"×6"×2½"	Rs	763	7	0	pr Lakh
Do	Do	9½"×4"×3"	"	536	"	"	Do
Peela	Do	12×6×2½	"	250	"	"	Do
Shama			"	6	"	"	pr 100 Cubic Feet

The Maximum number of Carts employed in bringing Firewood to the Works was 1500 pr day.-

1851-52

Hall's Brick making Machine turned out during this season 54,23,000 Kutcha Bricks the whole of which were piled into the Hindostani kilns in which they were baked.. Its Maximum rate of working was equal to 13500 Kutcha Bricks pr diem.-

Kutcha Bricks moulded on the Terraces of the Government Fields cost on an average Company's Rupees 3..13..4 pr Lakh

The Number of Kutcha Bricks moulded on the Government Fields:-		409,79,500
Filled into Kilns	313,35,400	
Used in repairing Kilns &c	52,26,800	
Loss by Rain, Breakage, &c	44,17,300	409,79,500

The Return from those filled into Kilns, was

Pukka Bricks	257,81,120	83 pr cents	On the Kutcha Bricks filled into Kilns
Peela Do	38,65,300	13 pr "	
Shama (Cubic feet)	37,820	4 pr "	

The Produce from the Hindostani Kilns was

Capra-

was Q 3,00,000 Pukka Bricks, making the Total results of the season as follows:-

Pukka Bricks	350,81,120
Peela Do.	38,65,300
Shama	37,820

The total Cost of the Seasons operations was Company's Rupees 305013 . 3 . 1

Giving (under the usual conditions) the following Average Rates for the Bricks in ordinary use.-

Pukka Bricks 12"×6"×2½"	Cost Rs	804	15	8	per Lakh
Do Do 9½"×4½"×3"	"	536	"	"	" Do
Peela Do	"	250	"	"	" Do
Shama.	"	6	"	.	per 100 Cubic feet

The maximum number of Carts employed per day during this Season in bringing Firewood to the Works was 2000.-

1852-53.

Hall's Brick Making Machines turned out during this season 5943400 Kutcha Bricks, The whole of which were filled into Hindostani Kilns.- The maximum working of these machines was at the rate of 14,000 Bricks per day each.-

Kutcha Bricks moulded on the Terraces of the Government Fields cost Cos Rs 90..7..9 per Lakh.-

The number of Kutcha Bricks moulded on the Government Fields was:-		426,25,220
Filled into Kilns	318,91,060	
Used in Repairing Kilns	52,44,248	
Loss by Rain &c	54,89,912	426,25,220

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The return from those filled into Kilns was

Pukka Bricks	262,43,880	82 p.cents
Peela Do	36,73,700	12 p.c. à
Shama	86,037	6 p.c. à

(On the Kutcha Bricks filled into Kilns)

The produce of the Hindostani Kilns was 90,00,000 Pukka Bricks making the Total for the Season as follows:—

Pukka Bricks	352,43,880
Peela Do	36,73,700
Shama	86,037

The Total Cost of the Seasons operations was

Company's Rupees 3,59,588.14.9

Giving (under the usual conditions) the following Average rates for the Bricks in ordinary use

Pukka Bricks 12"×6"×2½"	Co.Rs	940	14	6	p.m Each
Do Do 9½×4½×3"	"	650	"	"	Do
Peela Do 12"×6"×2½"	"	250	"	"	Do
Shama	"	6	"	"	p.m 100 Cub.feet

The great increase observable here in the cost of the Pukka Bricks is entirely owing to the enhanced price that had to be given for the Carriage of Fire wood which had annually to be brought from a greater distance as the Forests nearest to our works became cleared.—

1853-54

So far as this paper is concerned the Season of 1853/54 terminates on the 31st of March 1854; Up to that date the Roorkee and Nuhewan Brick Manufactories were most successfully worked to their utmost

capa-

capabilities, owing to the increased demand that was made upon them to meet the energetic measures which had been taken by the Executive Engineer to prepare the Aqueduct works for the reception of water early in April.- The Dhurmoor Manufactory was also steadily worked, but that at Selimpoor was closed on the 31st January on which date a sufficient number of Bricks had been prepared to complete the works in the neighborhood.-

Hall's Brick making Machines had made 22.36.500 Kutcha Bricks, 21.68.500 of which had been filed into Hindostani Kilns; The average maximum working of these Machines continued at 14.000* per day from each Machine

Kutcha Bricks moulded on the Terrace Platforms of the Government fields cost & Cost Rs 89.. 13. 0 per Lakh.-

*Note- On the front of Sheet just before making, for season close Bricks moulded daily by Machine

The number of Kutcha Bricks moulded up to the 31st March 1854 was:—		207.43.280
Filled into Kilns	21296000	
Used in repairing Kilns &c	3665200	
Loss by Rain, Wastage &c	329880	
In hand.-	1452200	207.43.280

So far as they were known (some Kilns necessarily remaining unloaded) the results of the Bricks filled into Kilns had been.-

Pukka Bricks	17880613	84 p hund	On the Kutcha Bricks filled into Kilns
Peela Do	2079100	9 per ..	
Thana Cubic feet	72922	7 per:	

The Hindostani Kilns contributed a further supply of 7500000 Pukka Bricks making the total number that had been sent to, or were available for, the works up to the

the termination of the period embraced by this Section, as follows:-

Pukka Bricks		253,80,613
Peela	do	20,79,100
Thama	(Cubic Feet)	72,952

The total Cost of the Operations during this period was

Rs 2,38,542.13.1

Giving (under the usual conditions) the following Average rates for the Bricks in ordinary use-

Pukka Bricks	12"×6"×2½"	Rs.	939	13	10	per Lakh
Do	9½"×4"×3"		650	..	.	do
Peela Do	12"×6"×2½"		250	..	.	do
Thama			6	..	.	per 100 Cubfeet.

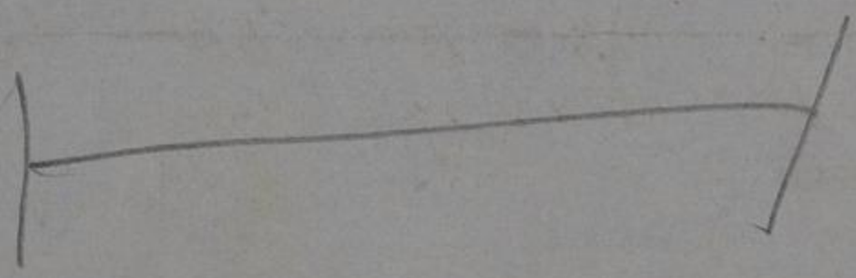
The following Condensed Abstract of the foregoing results will exhibit the extent of the Brickmaking Operations in the Northern Division of the Ganges Canal from their Commencement in 1842 to the 31st March 1854.-

	Pukka Bricks of all Sizes	Peela Bricks of all sizes
From Commencement to the end of June 1846	103,06,171	51,28,235
" June 1846 to October 1847	38,00,000	11,00,000
" Nov 1847 to October 1848	108,91,961	54,56,933
" Nov 1848 to do 1849	147,00,157	36,08,720
" Nov 1849 to do 1850	189,33,540	32,75,200
" do 1850 to do 1851	264,42,100	25,57,800
" do 1851 to do 1852	350,81,120	38,65,300
" do 1852 to do 1853	352,43,880	36,73,700
" do 1853 to 31st March 1854	253,80,613	20,79,100
Totals	1807,79,572	307,44,988
Grand Total	2115,24,530	

and a popular idea of its customs

may be given by stating that if the above number of Bricks were laid end-wise, they would form a line upwards of 40,000 Miles in length.—

The Memorandum appended to this paper was drawn up by Mr Finn for another purpose than this report, but it very appropriately takes its place here, and exhibits results during the whole of the period which it embraces, highly creditable to that Officers energetic management.—



Trap

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Memorandum of Operations in the Material Department, Northern Division Ganges Canal, drawn up by Mr James Finn, Executive Officer of Materials.-

The purport of the figured Sheet which accompanies this paper is to exhibit in a succinct yet comprehensive manner a Summary of my principal doings as Executive Officer of Materials at Roorkee: and I shall here endeavour further to elucidate such points as appear to me to call for remark. I shall, however, confine myself in this Memorandum as I have done in the figured Statement, to the staple articles of building Materials supplied to the Executive Engineer, viz: Bricks - Lime - and Soorkee; deeming it undesirable to hazard being tedious by entering on such comparatively insignificant items as Cattle, Timber, and Miscellaneous Materials.-

2.- The Number of Pukka Bricks expended on the works of the Northern Division since the Material Department has been in my hands, together with those now in Store, is as follows:-

Season	Numbers
Season of 1847/48	95.70.092
1848/49	160.98.194
1849/50	216.71.221
1850/51	255.93.135
1851/52	338.77.271
1852/53	339.39.064
From 1st August 1853 to 31st March 1854	299.52.861
Total	1707.01.838

besides 200,68,040 Peela Bricks and 665,816 Cubic feet of Khama: Of the above 1610,91,899 Pukka Bricks were of the standard size of 12"

12"x6"x 2½" and were manufactured at an average rate of Rs 995..3..0 pr Lakh in=cluding all expnses of Carriage and Stacking.- The demands on me for this Material, it will be seen, were far beyond what was originally anticipated, yet I am happy to say that on no occasion were the works stopped from the supply running out.- I would invite attention to the Column shewing the Cost of Manufacture of the Standard Bricks. The first Season's work may be regarded as expnrimental; after which notwithstanding the enormous Sums expended, as pr Margin† on Dead Stock, nearly all of which has been charged off, it will be seen that up to November 1829, there was a steady and gradual reduction in rate which at this pnriod reached the minimum of Rs 780, or with Carriage &c Rs 900 pr Lakh; and in wood kilns and under ordinary circumstances, I do not believe they would ever be cheaper at Roorkee.- In May 1832, there is again a rise in price, as might naturally be ex=pected, owing to the greater distance which Firewood had to be brought.- At the Com=mencement of oprations this distance was 7 miles; latterly it has been 22 miles.- The supply of fuel for my kilns has been my chief anxiety. it has cost me from 10 to 15 Rupees pr 100 Maunds; and I have brought in and consumed the enormous quantity of 91.55.734 Maunds, clearing away in so doing from 80 to 100 Square Miles of Jungle!—

† Kilns Rs 27400
Terraces ... 24654
Wells " 3026
Total Rs 55080

foot note

3. I may here add that the whole of the Bricks made during the first season were baked in large Kilns on the old "English" pattern.- Towards the close of the following season, a few expnrimental Clamp flame Kilns were tried, and with such fa=vorable results, that ever since, they have been

been in full use, and the "English" ones entire
=ly discontinued.-

4.- The Quantity of Lime furnished to our works is Maunds 1938.200 viz^d:

Period when Supplied			Quantity Maunds	Seers
	Season of	1847/48	171.024	20
	Do	1848/49	312.253	"
	Do	1849/50	214.215	12½
	Do	1850/51	209.149	30
	Do	1851/52	314.011	37½
	Do	1852/53	302.896	27½
	Part of Do	1853/54	354.448	32½
	Total Maunds		1938.200	-

issued at an average rate of Rs 26..3..0 pr^n 100 Maunds.. The established rate of this Material when I assumed charge was 30 Rupees pr^n 100 maunds; and I was given to understand that even a higher price had been paid for it- As our work progressed and competition was engendered, I thought an opportunity offered for getting this arti=cle at a reduced rate, and to a certain ex=tent I succeeded in the second season of our operations.. In the following year, how=ever, I proceeded too far- I paid no more than Rs 23..12..0 pr^n 100 maunds: the con=sequence was that the supply fell off: Con=tractors would not come forward and I was reduced to the necessity of advancing the rate by Rs 1..8..0 pr^n 100 maunds- It will be seen from the Statement accompany=ing that ever since November 1850, the price of Lime has remained fixed at Rupees 25..4..0 pr^n 100 maunds, and I be=lieve this to be a fair rate both for Con=tractors and Government.-

5.- The issues of Sookee annually, including Stock now in hand have been:-

Season

Period when supplied			Quantity	
			Maunds	Sers
	Season of	1847/48	54,367	10
	Do	1848/49	192.937	30
	Do	1849/50	418,867	30
	Do	1850/51	442.751	30
	Do	1851/52	619.047	25
	Do	1852/53	672.268	25
Part of	Do	1853/54	1130,896	15
Total Maunds			3531.137	5

at an average of Rs 12..9..0 pr 100 Maunds
The rate when I joined was Rs 14..12..0; it has since naturally fluctuated with the Cost of Bricks; hence we find it reduced to Rs 12..8..0, and then to 12 pr 100 Maunds: and latterly it has risen to Rs 13..8..0.—
6.— I have been very fortunate in my extensive dealings with Contractors for Puzawah made Bricks, Lime and Carriage of Firewood.. Of Brick Contractors I had from 40 to 50 in constant employ, about the same number of Lime Contractors, and sometimes as many as 400 Contractors with 2000 Carts bringing firewood from the forest.— Every Rupee earned by my numerous Contractors was paid to them in my presence, and although I have been obliged to make large advances to get them to work, and to retain them afterwards, I have not to this date lost One pie by the Contractors for Bricks and firewood; but I did lose about Rs 150 by the Lime Contractors, two of whom died before their Contracts were completed, and they were in such poor circumstances that they left nothing but their Starving families behind them.—
7.— In conclusion, I would advert to the large Sum of money which has passed through my hands for the Supply of Materials for the Northern Division and

endeavour

endeavour to shew, that it has been, at
least, not unprofitably expended. The
Sum total of money laid out on Materials,
exclusive of Establishment pay and
Current Expenses is, as per accompanying
Statement, Cos Rs 23.18.398..4..4, which,
being spread over 78 months, gives an
average Monthly Outlay of Rs 30107..10.8
The increased charges for Supervision over
this Outlay - I mean my own Salary,
that of my Office Establishment and
Current Expenses - for the same Staff of
Overseers would necessarily have been
maintained if the Executive and Material
Departments had not been separated -
have been as nearly as possible, 500 Rs
per Mensem, or 1⅔ per cent - Now to look
at the direct saving to Government effected
by reduction of rates: The average Cost of
Bricks during my first seasons work, viz:
Rs 12.14.12.0 per Lakh, may be assumed
as the rate of manufacture when I took
charge - My Bricks on the whole have
come to Cos Rs 995..3..0, equivalent to a
saving of Rs 2.19..9..0 per Lakh, or on
1610,94.899 Bricks 12" × 6" × 2½" Comp'y. Rs
402032..7..4 - Similarly with Lime, the
reduction has been Rs 30 - 26..3..0 = 3..13..0
per 100 maunds: or on the total supply
Cos Rs 72,893..14..0.. And in respect to
Sookee the reduction is equal to Rs 2..3..0
per 100 maunds, or on 3531.137 maunds
it is Cos Rs 7721.3..10..0 - Collecting these
Sums we get

Saving on Bricks	Cos Rs	402032	7	4			
on Lime	"	72893	14	..			
on Sookee	"	7721.3	10	..	552169	15	4
Deduct. Expense of Supervision for 6½ years @ Rs 6000/- per Annum					39000	..	.
Nett. Saving to Government					513.169	15	4

being

being 17·93 prs/bend.—

8.— I shall say nothing of the dif=
=ficulty of obtaining Materials in large
Quantities at any price - of providing
carriage for the immense Stocks of fire=
=wood required for my kilns - of transpot
=ing Lakhs of Cubic feet of Lime annually-
in short of making arrangements for
Materials generally on so very extended
a Scale as was indispensable in the
Northern Division; but allow the simple
figures given above to Spak for them=
=selves, confidently trusting that the
results which have been Shewn in this
Memorandum will prove satisfactory

(Signed) James Finn
Ex: Officer Northn Dn: Ganges Canal

Statement or Abstract of Cash received to account of Materials, and of Issues of Materials to Works, with Rates of Each.—

Period	Cash advances to Ex. Officer of Materials			Issues to Works: Pukka Bricks 12"×6"×2½"	Pukka Bricks (machine) 9½"×4"×3"	Pukka Bricks of sizes	Pucka Bricks	Jhama	Stone Lime		Soorkee		Firewood brought on Works	Pukka Bricks 12"×6"×2½" per Lakh			Stone Lime per 100 maunds			Soorkee per 100 maunds		
	Rupees	as	p	Number	Number	Number	Number	Cubic feet	Maunds	Srs	Maunds	Srs	Maunds	Rs	as	p	Rs	as	p	Rs	as	p
To	R	A	P																			
30th April 1848	195.398	4	4	6043.090	"	266.960	24,46,645	11,840	83315	25	7.066	20		* 1214	13	1	29	9	7	14	10	9
31st July "	105,000	"	"	32.39.554	"	20.488	2,17 398	36858	87708	35	47,300	30	657,546	* 1300	8	8	30	"	"	14	12	"
31st Octr "	52,000	"	"	41.84.866	"	15.080	10,39 360	94,341	19475	15	23.673	25		* 1149	8	"	30	"	"	14	12	"
31st January 1849	111,200	"	"	53.57.615	"	508.012	8,86 918	22,789	102,717	12½	30.604	35		* 1066	13	10	30	"	"	14	12	"
30th April "	134,500	"	"	33.47.299	"	"	4,67,384	42,081	98.974	27½	84.828	"		850	"		30	"	"	12	8	"
31st July "	79,400	"	"	26.66.822	14,000	4.500	4.14.523	65,202	91,085	25	53.961	10	1347498	800	"	"	28	"	"	12	8	"
31st Octr "	14,700	"	"	37.01.300	18.800	12.140	4.28.274	50	18	30	25.926	10		800	"	"	28	"	"	12	8	"
31st January 1850	63,200	"	"	52.20.651	102.708	"	12.52.234	33,528	22.802	22½	105.471	25		780	"	"	23	12	"	12	"	"
30th April "	107.000	"	"	72.58.166	264.200	"	8,63.209	45.771	65,222	15	179.429	10		780	"	"	23	12	"	12	"	"
31st July "	80,000	"	"	47,68,556	321.700	"	4.48,092	22.191	126.371	25	108.040	25	1498.200	780	"	"	23	12	"	12	"	"
31st Octr "	44,500	"	"	36.94,683	180.052	"	2.46.160	50	364	15	50.361	20		780	"	"	23	12	"	12	"	"
31st Jany 1851	75.000	"	"	67,91.037	230.800	150	6.80,734	700	43.365	25	57,324	30		780	"	"	25	4	"	12	"	"
30th April "	108.000	"	"	65,48.520	203.250	"	7.70,349	29,864	114.875	"	156.163	35		780	"	"	25	4	"	12	"	"
31st July "	75.000	"	"	75.74.328	370.315	"	6,91,590	35.932	110.544	30	178.901	25	1241,755	780	"	"	25	4	"	12	"	"
31st Octr "	37,000	"	"	51.22,708	722.260	500	3.06.850	"	1.532	20	68.305	5		780	"	"	25	4	"	12	"	"
31st Jany 1852	111.000	"	"	96.22.391	234.300	200	10.65.216	22.546	91.712	"	278.555	15		780	"	"	25	4	"	12	"	"
30th April "	165.000	"	"	106.41.669	642.713	"	14.69.066	"	103.634	30	126.910	35		780	"	"	25	4	"	12	"	"
31st July "	107.000	"	"	63.94.176	488.900	7460	10.67.070	15.274	117.132	27½	145.276	10	22,81,507	880	"	"	25	4	"	12	"	"
31st Octr "	35.500	"	"	57.38.834	893,435	30900	12.07,582	7.674	856	16	41.261	20		880	"	"	25	4	"	12	"	"
31st Jany 1853	75.000	"	"	59.26.946	528,760	174,459	11.66,102	10.742	54.217	10	200.578	"		880	"	"	25	4	"	12	"	"
30th April "	130.000	"	"	111.53.925	464.350	60,668	8.44.760	49.134	119,303	5	238.637	"		950	"	"	25	4	"	12	"	"
31st July "	105.000	"	"	85.62.097	305,800	98.890	5.97,360	18.487	128.470	2½	191.792	5	12.29,228	950	"	"	25	4	"	12	"	"
31st Octr "	83.000	"	"	58.18.315	593,250	118.011	1.96,120	40.039	18.141	27½	143.644	15		950	"	"	25	4	"	13	8	"
31st Jany 1854	155.000	"	"	130.38.573	875.280	209.598	10.84.590	3.875	233.531	27½	373.792	5		950	"	"	25	4	"	13	8	"
31st March "	100 000	"	"	56.78.784	311.150	309.900	2.14.504	56.845	102.775	17½	438459	35	9.00,000	950	"	"	25	4	"	13	8	"
	2348.398	4	4	1580.94.899	7769.023	1837.916	200,68.040	665.816	1938200	"	3356.137	5	91.55.734									
In Store about	-	"	"	30.00.000	"	"	"	"	"	"	175.000	"	"									
Total	2348.398	4	4	1610.94.899	7769.023	1837.916	200,68.040	665.816	1938200	"	3531.137	5	91.55.734									

* These four rates include Carriage and Stacking - In February 1849, I was relieved of the Provision of Carriage for Bricks, but Capt Goodwyn has ascertained from averages struck on large quantities that Rs 120/14/5 cover all Expenses of Carriage &c.a. If, therefore, 120 Rupees be added to the succeeding rates, the total cost of Bricks to the Works will be obtained.—

(Signed) James Fizzy
Ex Officer North Dr Ganges Canal

APPENDIX

B

REPORT OF A COMMITTEE

ASSEMBLED BY GENERAL ORDERS COMMANDER IN CHIEF,

DATED 16TH SEPTEMBER, 1845.

UNDER INSTRUCTIONS FROM THE RIGHT HONORABLE

THE GOVERNOR GENERAL OF INDIA IN COUNCIL.

President:

MAJOR W. E. BAKER, ENGINEERS,

Members:

SURGEON T. E. DEMPSTER, HORSE ARTILLERY,

LIEUTENANT YULE, ENGINEERS.

AGRA:

WM. H. HAYCOCK, SECUNDRA ORPHAN PRESS.

1847.

AGRA:

Wm. H. Haycock, Secundra Orphan Press.

1847.

REPORT OF A COMMITTEE ORDERED TO ASSEMBLE BY G. O. C. C.

Dated the 16th September, 1845.

EXTRACT FROM GENERAL ORDERS.

"Under instructions from the Right Honorable the Governor General of India in Council, the undermentioned "Officers are directed to form themselves into a Committee to assemble at such places and on such dates as may be fixed "by the President, for the purpose of reporting on the causes of the unhealthiness which has existed at Kurnaul, and other "portions of the country along the lane of the Delhi Canal ;—the Committee will also report whether an injurious effect "on the health of the people of the Dooab is, or is not likely to be produced by the contemplated Ganges Canal."

PRESIDENT :

MAJOR W. E. BAKER, *Engineers.*

MEMBERS :

SURGEON T. E. DEMPSTER, *Horse Artillery.*

LIEUTENANT H. YULE, *Engineers.*

Georges Bernard

Sup D

REPORT.

Roorkee,
3rd March, 1847.

The conduct of the investigation entrusted to our Committee, and detailed in the annexed General Order, involved the necessity of personally examining the districts irrigated by the existing canals, and such other localities as seemed best suited for a fair comparison with them. For this purpose, the Committee met at Kurnaul on the 30th November, 1845, and proceeding southward had made considerable progress in the examination of the irrigated districts west of the Jumna, when they were summoned to military duty with the army of the Sutlej. On the 1st November, 1846, the enquiry was resumed, and has continued without further interruption.

2nd. The route followed by our Committee may be traced on the accompanying sketch map. It was prescribed in some measure by the official engagements of Major Baker, whose inspection of the canals, &c. was necessarily performed in conjunction with his duties as a member of the Committee. It will be seen, that we have examined the irrigated and unirrigated districts on both banks of the Jumna, that we have visited the Nujufghur jheels, and have followed the proposed course of the Ganges canal for 83 miles, viz. from Hurdwar to the latitude of Meerut. In the course of this enquiry, we have travelled about 1400 miles. We have visited more than 300 inhabited localities, and have personally examined upwards of 12,000 individuals of all ages.

3rd. It was suggested by our medical member, and will be generally admitted, that a fair comparison of the sanatory condition of different districts must be founded on observations taken within a very brief period of each other, and under circumstances as nearly as possible similar. The observations taken in 1845 were, therefore, useless for our present purpose, and the necessity of completing our enquiry within a period

limited to about 3 months, compelled us to restrict our observations to the bodily condition of the people and to those more obvious circumstances which all modern authority concurs in pronouncing to be those most concerned in the production of disease.

4th. In the commencement of our investigation, we had hoped to derive much assistance from the results of enquiries conducted by our own native agents, and at our instance by the establishments of the Revenue and Canal departments. We have now before us an immense mass of reports obtained from such sources, but they are in general so vague and unsatisfactory, and are so little corroborated by our own personal observations, that we were unwilling to incur the labor involved in arranging and digesting them, with so little prospect of ultimately obtaining trustworthy results.

5th. Our principal object was to ascertain what relation subsisted between certain physical conditions of the different districts, and the liability of their inhabitants to miasmatic fevers. The former could be noted with some degree of certainty, but in the absence of official medical statistics, and with frequent reason to doubt the accuracy of oral testimony, although collected by ourselves, we could not obtain even an approximation to a fair comparison of the past and present sanatory condition of the inhabitants of different localities. In this difficulty, it was suggested by our medical member, that the condition of the spleen in any number of individuals would be a fair test of the probable frequency and degree in which they had suffered from malarious influences. Having satisfied ourselves of the propriety of this test, and finding it easy of application, we determined to adopt it, and have based on the results so obtained the most important of the conclusions at which we have arrived. In the Appendices B and C. will be found a memoir by Mr. Dempster, stating the medical grounds for the adoption of this test, and describing the method followed in applying it.

6th. The present season, in which our observations were taken, has been a generally healthy one, and was preceded by a season scarcely less favorable. It is also separated by 8 or 9 years of good harvests from a season of drought, a circumstance decidedly in favor of unirrigating villages which have had abundant time to recover from any sickness that

might have been entailed upon them by the unmitigated hardships of famine.

7th. Amongst the instructions furnished for our guidance from the Adjutant General's office, we find a series of questions, on each of which His Honor the Lieutenant Governor, North Western Provinces, has called for our recorded opinion. These questions embrace nearly all the important points of our investigation, the results of which cannot perhaps be shewn in a more intelligible form than that of consecutive answers to His Honor's interrogatories, as follows :—

8*th*—First. *How far is the unhealthiness which has prevailed of late years at Kurnaul, Delhie, Hansi, Hissar and Rohtuck and in the villages irrigated from the canal attributable to the existence of the canal, and to irrigation from it?*

Reply I.—We have obtained satisfactory proof that an extensive epidemic influence, in whatever it may have consisted, or however produced, undoubtedly pervaded a large portion of the North Western Provinces of late years, and especially during and after the rainy season of 1843. To this we would partly attribute the sickness which occurred in the canal irrigated districts, where, however, it is also certain, that the disease was generally, though not universally, more prevalent and severe than in other situations.

9*th*.—Second. *Did similar unhealthiness prevail at the same time in other parts of the country not irrigated from the canal and beyond the reach of its influence? If so, to what cause is that unhealthiness attributable? Was the type of disease in the two cases the same?*

Reply II.—Nearly all places within the North Western Provinces also suffered from fever at the same time, and in a degree greater than usual.* We have, moreover, every reason to believe, that in certain situations neither irrigated from the canal nor within reach of its influence (as at Kythul, in the vicinity of the Nujufghur jheels, and in the khadir of the Jumna, &c.), fevers prevailed to an extent and with an intensity, as great as in the worst of the canal villages. The season of the year at which the disease appeared, its symptoms, progress, and consequences, would mark it to have been every where of

* See Appendix D.

the same type, viz. the endemic (remittent and intermittent) of the rainy season, but every where, and especially in naturally malarious localities, greatly aggravated by the constitution or peculiarity of the season.

10*th*.—THIRD. *If you consider the canals to have been the cause of unhealthiness along their course, have you any grounds for thinking such to be the unavoidable result of canal irrigation, or is it attributable to other causes, such as intercepted drainage, flooding from canal, peculiarity of the soil irrigated, &c. ?*

Reply III.—By far the greater part of the evils we have observed have not been the necessary and unavoidable results of canal irrigation. In all situations where mischief was prominently marked, the natural drainage of the country had been checked or interfered with, stiff and retentive soils saturated with water, and natural disadvantages of site enhanced by excess of moisture.

11*th*.—FOURTH. *Can you suggest any means whereby the agricultural benefit of canal irrigation may be continued to the country at large while Military Cantonments or large towns may be saved from the risk of unhealthiness?*

Reply IV.—The effects of canal irrigation appear to be remarkably local, almost strictly so: three miles would probably be a safe distance; but if irrigation were prohibited within a circle of five miles radius round a large military station, its salubrity would not in our opinion be affected.

12*th*—FIFTH. *Can you suggest any change in the lodging or mode of life of the agricultural population within reach of canal irrigation which would render them less liable than at present to any unhealthy influence occasioned by the canals?*

Reply V.—We feel doubtful whether any suggestion proceeding from authority, as to mode of life, exposure, food, clothing and construction of houses, would be adopted and voluntarily practised by the agricultural population. The best and most efficient prophylactics of this class, naturally come with competence and ease, but much might be done to improve the salubrity of village sites, viz. to stop irrigation within 200 yards round all canal

villages, and to plant a double row of trees round the unirrigated space,—to deepen all good village tanks, and to keep them full of water all the year round,—to drain all shallow pools in or about villages, or to convert them into proper reservoirs of water—and, wherever it may be possible, to improve the drainage of village sites. It would be no hardship on a new canal to make such works an invariable condition of obtaining water for irrigation. Cleanliness is of much though not of such vital importance as the measures above recommended; but we fear no rules on this subject could be generally enforced.

13*th.*—Sixth. *Looking to the circumstances of the eastern Jumna or Saharunpoor canal, do you find that the effect of the canal irrigation on the health of the inhabitants has been the same there as on the west Jumna or Delhie canal? If not, how do you account for this difference in effect?*

Reply VI.—The eastern Jumna canal furnishes examples of some of the best and worst results of canal irrigation. In the north and south divisions, where the soil is light, the drainage perfect, and irrigation carried on chiefly by "Rajbuhas," we perceive all the blessings and scarcely any of the evils of a canal. But in the centre division, where the drainage of the country has been greatly obstructed, and the soil is generally more stiff and clayey, the effect on the health of the inhabitants has been the same in kind, and nearly in degree, as in the objectionable portions of the Delhie canals.

14*th.*—Seventh. *Do you suppose that the contemplated Ganges canal will or will not exercise an injurious effect on the health of the people of the Dooab, over the whole of which it is intended to extend its influence? If you are of opinion that it will, can you propose any remedy or palliatives which will not involve the entire*

Reply VII.—In the course of our enquiries on the existing canals, we have found salubrity to depend in a great measure on the nature of the soil and the efficiency of the surface drainage. In the districts which it is proposed to irrigate, the obvious geographical features of the country enable us to pronounce with some confidence, that an efficient drainage, if not every where existing, is at least generally attainable. On the proposed line of the canal from Roorkhee to Meerut, we observed the soil to be light and friable; but without an extended examination, we cannot pronounce what proportion

abandonment of the undertaking?

of the remaining districts of the Dooab is characterized by similar soil. It can scarcely be hoped, however, that in the whole length of the proposed canal and its branches, some localities will not be met with, naturally and irremediably unfavorable to irrigation, and in which disease analogous to that found on the existing canals may not be expected to develope itself. On the other hand, if attention to drainage be made an absolute condition of participation in the benefits of the canal, an improvement rather than a deterioration of the general salubrity, may, in many instances, follow the introduction of canal irrigation. On the whole, we consider ourselves warranted in anticipating, on the Ganges canal, a far less amount of contingent evil than has been experienced on those of the Jumna, which were originally constructed without reference to many important points which have been especially kept in view in projecting the present work. And more especially in drawing inferences from results on the Delhie canal, great allowances should be made for the natural disadvantages of the country through which it flows—when compared with the Dooab generally. It is a remarkable feature of the "bangur" land bordering the right bank of the Jumna, that its drainage flows from, instead of towards, that river. The slope of the country, which is to the south-west, amounts to 1 foot or 1 foot 6 inches per mile, and is not sufficient to prevent even a slight obstruction from interfering with the flow of water. In subordination to the general slope, there are minor undulations, the excess of slope in one part being compensated by the absolute want of it in another. In such cases, the drainage of the higher lands collects in the lower, and from the latter there is no efficient escape. This is exemplified on a large scale in the Nujufghur jheels, and to a less degree in many other localities. The Dooab, on the other hand, is intersected by deep depressions, sometimes with the character of valleys, sometimes of ravines. These, except in a few instances, receive and rapidly carry off the surplus water of the country.

Taylor

15. With reference to the latter part of this question, we have prepared a memorandum of measures connected with the execution of the Ganges canal, which we would strongly urge upon the attention of Government. With the details of these measures, which are of a technical

nature, we have not encumbered this report, but they will be found in Appendix F.

16. In addition to the above replies, it is proper to state our opinion of the effects produced by canals on the population of the irrigated districts, as regards their enjoyment of life and physical efficiency as agricultural laborers. During the cold season of 1846-47, (a healthy year) no obvious bad effects were perceptible in the adult population. The men generally looked healthy, happy, and thriving. The autumn crops were all gathered in, and the spring crops sown. The villagers on the western Jumna canals are better clothed and housed, and have more appearance of wealth and comfort than those off the canal. In a few of the worst localities, the aspect of the children was decidedly sickly: they were puny and pot-bellied. It must further be borne in mind, that our observations were made at a favorable season, and that we not only refrained from calling for the sick, but systematically discouraged their being brought forward.

17th. In our examination of districts unconnected with the canals, we have included some in which well irrigation is habitually practised, and in which we have found the population in a slight degree more subject to malarious diseases than in the totally unirrigated districts. We would, however, hesitate in attributing this difference to the mere circumstance of irrigation. It may perhaps be as justly ascribed to the abundance of springs and limited depth of wells, which are essential conditions of extensive well irrigation.

18th. In endeavouring to account for the observed difference of salubrity between well and canal irrigation, we beg to point out some material differences in the circumstances under which they are severally practised. Well irrigation is chiefly resorted to during the healthy season of the year: the water obtained with labor, is used with economy, and the natural moisture of the soil is not increased by the water being transferred from a lower stratum to the surface. Canal irrigation, on the other hand, is practised throughout the year, being applied even during the rainy season to the cultivation of rice. The water being more easily obtained is more likely to be used in excess, and such portion of it as may be absorbed by the soil increases by so much its natural humidity. It

may be added that foreign alluvial matter is more likely to be held in suspension in canal water, than in that obtained from wells.

19th. The pecuniary advantages of canal irrigation both to Government and to the farmer, are, we believe, fully recognized, and are so well understood by the cultivators themselves that they would willingly take their chance of the contingent evils of irrigation, in order to secure its benefits. Of this, we saw abundant proof in the course of our investigation. It would, however, have been an important test of the national value of canal irrigation, could we have accurately ascertained its effects on the density of the population, and whether the augmented capacity of the soil for supporting life compensated for the increased activity of influences inimical to its duration. In the hope of determining this question, we obtained from the revenue authorities certain returns, of which an abstract will be found in Appendix G., and which shew a marked difference in favor of irrigated lands. It is, however, to be regretted that the census forming the basis of these returns was taken several years ago, and may therefore not be strictly applicable to the existing condition of the country.

20th. In the foregoing paragraphs, we have confined ourselves to general conclusions, fearing lest, by entering on the consideration of local details, we should extend our report to an inconvenient length. But our attention having been particularly called to the station of Kurnaul, we beg to offer a few remarks shewing briefly the causes to which we attribute the late sickness at that station, and the extent to which they may be removed or palliated.

21st. The insalubrity of Kurnaul has been ascribed to various causes :—to the prevalence of an epidemic influence, of late years, over the North Western Provinces—to its proximity to the Jumna khadir on the east, and to the unhealthy flats of Kythul on the west—to the stiff and retentive nature of its soil—to the swamps bordering on the canal—to the extent of rice cultivation—and to the naturally imperfect drainage, being still further obstructed by the canal embankments. Each of these causes, and especially the first named, have, in our opinion, contributed to the unhealthiness of Kurnaul. Some of them are obviously irremediable, but we are satisfied of the practicability of reclaiming the

canal swamps, of improving the surface drainage by carrying off the superfluous water under the canal by two tunnels to the Jumna, and of prohibiting irrigation within two miles of the Cantonment pillars. We have no doubt that the adoption of such measures would be attended with beneficial results; but believing that the level of the springs has been permanently altered, and the under strata of the soil saturated with moisture, we cannot confidently prognosticate that they would ensure the complete restoration of salubrity.

22nd. In the foregoing paragraphs, we have confined ourselves to general conclusions, purposely omitting the chain of induction by which they have been formed on the observed facts, as recorded in the figured abstracts in the Appendix E. A full discussion of the complicated considerations which have influenced our opinions would have extended this report to an undue length, and might probably have hindered rather than facilitated the formation of a correct judgment on the important question at issue. The facts, however, are recorded for reference, and will be found, on careful examination, to support our opinions.

23rd. In conclusion, we beg to record our obligations to the Honorable the Lieutenant Governor, North Western Provinces, for the assistance he has afforded us, both privately and officially, in the prosecution of our enquiries. On his requisition, we have received from the Madras Government a report on a remarkable epidemic that pervaded the southern districts of that Presidency in 1809, 1810, and 1811, an abstract of which will be found in Appendix H., and at his suggestion we have obtained the appended reports from Drs. Kier and Collyer, shewing that tank irrigation, as practised in certain districts of Rajpootana, is consistent with a high degree of salubrity. These documents possess much interest with reference to the subject of our enquiry, and have had their due influence on our general conclusions.

(Signed) W. E. BAKER, *Major, Engineers,*
President.

(Signed) T. E. DEMPSTER, *Surgeon,*
1st Bgde. Horse Artillery,
Member of Committee.

I fully concur in the substance of this report, but as a change in my ordinary duties since I was appointed a member of this Committee has prevented my taking any active share in its proceedings, my signature here is merely formal.

(Signed) H. YULE, *Lieutenant, Engineers, Member of Committee.*

APPENDIX A.

I would willingly have confined myself strictly to the facts before our Committee, did I not consider it necessary, in order that these very facts should have due weight and consideration, first, fully to meet an argument often advanced by intelligent persons interested in canal irrigation, and believed by them so unanswerable, as alone to prove the doctrine of malaria a mere fiction of medical writers, and to render all further enquiry unnecessary, viz., that some marshes can be pointed out which do not cause fevers to any extraordinary extent; and some perfectly dry localities, where fevers of a very malignant nature abound.

That certain local peculiarities are *generally* connected, as cause and effect, with certain diseases of the human body, is no hypothesis of any set of medical speculators, but a belief which has forced itself on the conviction of mankind in various ages and countries. What those conditions are which are essential to the production of endemic disease, and what are accidentally associated with them, how the poison is evolved, and what are its sensible properties and chemical composition, have indeed furnished ample grounds for medical speculation and controversy; but the general proposition itself is as fair and legitimate an induction from observed facts, as any within the whole range of science.

Exceptions do not confirm a rule, but neither do they overturn a fair induction. They only shew that our knowledge is incomplete, and the whole law of the case not fully understood. If, in the exact sciences, residual phenomena are constantly occurring; something happening which was unlooked for; something expected which does not take place; how much more may they be anticipated in such a science as medicine, where the sources of error are at once so numerous and perplexing?

Mankind, not physicians alone, have agreed, that typhus fever is a highly contagious disease. Suppose (what would not be difficult) that I collect a dozen authentic cases of persons, who have freely exposed themselves to this contagion, and who, notwithstanding, entirely escaped the disease, am I therefore to shut my eyes to the thousands of instances in which the complaint was communicated under like circumstances, and to reject the whole doctrine of contagion as untenable? Surely this would be generally condemned as a dangerous and inexcusable error! The human race have, at least, as deep a concern in the laws of malaria, as in those of contagion.

It is a remarkable and most important fact, that the diseases believed to arise from malaria, are, beyond all comparison, more prevalent during and immediately after the periodical rains in India, than at any other season of the year; and that this is precisely the time when the conditions everywhere alleged to be necessary to the production of that poison, are also, beyond all comparison, most abundant. At some places, there may be more, and at others less; in some years more, and in others less; but the truth of the general remark may be verified, in this country, at all places, and in all years.

When we remember the feeble affinities which hold together the constituents of vegetable matter, the numerous and totally dissimilar combinations into which they may enter, and the seemingly trifling accidental circumstances which may determine the nature of the new compound, it is not unreasonable to believe, that a *something* capable of causing human disease, may be evolved during the decomposition of such substances, under the action of heat, moisture, and electricity; or to conceive, that unappreciable, or at least unnoticed modifications of these conditions, or of the chemical state of neighbouring bodies, may alter the nature of the expected product, and obstruct the formation of the poison when most confidently looked for. For instance, we may make all the usual arrangements for vinous fermentation; an unexpected and unobserved change takes place in the temperature or electric condition of the atmosphere, and *vinegar* not wine is the result. Is malaria alone to be a constant and unvarying product of such complex operations, even though all the ordinary conditions are apparently present?

Again, if we admit that a certain class of fevers arise from malaria, does it necessarily follow, that all endemic fevers must originate in the same cause, or that all malaria is necessarily one and the same? Or who has demonstrated that malaria, like carbonic acid gas (an aëriform fluid, to which in some points it bears a striking analogy) may not be evolved under several and very different apparent conditions?

All our previous knowledge and experience would lead us to suspect some mischief from irrigating canals in such a climate as that of India, especially, if not expressly constructed so as to preserve the drainage of the country, and effectually to control the immoderate use of the water; and all I contend for is, that the question be tried and decided by the facts strictly bearing on the case before us, and not by a few exceptions, however striking or inexplicable, found in other distant situations or countries.

(Signed) T. E. DEMPSTER, *Surgeon,*
1st Brigade Horse Artillery,
Member of Committee.

APPENDIX B.

The first indispensable step in the present enquiry was to obtain some certain mode of determining the relative salubrity of different districts irrigated by the canals, irrigated by wells, or altogether unirrigated. In most European countries at the present day, this would have been easy enough, by the mere comparison of the known medical statistics of the several localities under examination; but in India, the difficulties were at first sight almost insurmountable. Here, we had no record of diseases, births, deaths, and population, to which we could refer. A native's account of the healthiness of his own town, or village, even for one season, is the loosest and most vague of statements, and if employed to collect positive data, his written report is not a whit more to be depended on. The aspect of the people is always a matter liable to error and difference of opinion; and the important subject of longevity cannot even be approached, for no native knows his own age correctly, least of all those advanced in years. The records of military hospitals were good and valuable data as far as they went; but they applied only to a few widely distant points, and referred to a class of subjects, differing in all important particulars from the native inhabitants of the towns or the agricultural population of the country.

In this difficulty, it occurred to me, that the inhabitants of malarious countries, but especially the native inhabitants of unhealthy districts in India, often carry in their own persons a record of past suffering, which can at all times be easily read, and which no one can either falsify or suppress. This is enlargement of the spleen, a disease to which the native of India is peculiarly liable, and which, if not the invariable consequence of miasmatic fever, is so constantly associated with it, that the one may (on the large scale) be safely taken as the measure of the other, or at least, of that malaria from which both unquestionably spring. But as this is a test which has never before (to my knowledge) been used for the same purpose, and as many of our conclusions are based on the results with which it has furnished us, I trust I shall be permitted to enter somewhat fully into the subject.

There is no fact more generally known or unhesitatingly admitted by medical men, than that disease of the spleen is one of the most frequent consequences of malarious fevers. To enumerate all the authorities on this point, would be to quote most of the respectable writers on these subjects; but that Government may appreciate the value of the test I chiefly depend on for the purpose of determining the comparative intensity of malaria in different localities, it will be proper to cite a few passages from two recent and well known works, by authors, respectively, of European and Indian experience.

" In moist countries, whether warm or temperate, they (diseases of the spleen) " are endemic, as in Italy, Holland, South America, and some parts of India, *in* "*fact wherever malaria exists.*"

" The most frequent causes of enlarged spleen are ague and remittent fever." —*Cyclopædia of Practical Medicine.*

" The most part of the cases of vascular enlargement of the spleen in this " country (Bengal) follow intermittent and remittent fevers, and tumid spleen " may be stated as the most invariable consequence of acute and debilitating dis- " ease among children of weak constitutions in Bengal.

" The assemblage of constitutional symptoms described in the foregoing pages " constitutes *the endemic cachexia of those tropical countries that are subject to* " *paludal exhalations ;* the enlargement of the spleen is the most frequent attend- " ant on that cachexia ; and its increase or subsidence generally corresponds with " the unfavorable or favorable changes which are taking place in the constitution.

" Disease of the spleen is much more frequent in those years in which the " most obstinate, fatal, and protracted remittents prevail." " The history of the " fevers of St. Domingo and of Minorca by Jackson and Cleghorn shew how fre- " quently disease of the spleen is connected with the autumnal fevers of these " countries. But great heat is not essential to the production of that disease. It is " the autumnal endemic of Holland, of the low parts of Hungary, of the marshes of " Lombardy ; and it is by no means rare in the fens and marshes of England. In " fact, enlargement of the spleen *is frequent wherever intermittent and remittent* " *fevers prevail.*"— *Twining's Diseases of Bengal.*

Such passages might be multiplied to a great extent, but the above will, I hope, suffice to establish the value of this kind of evidence, as a probable measure of the existence and intensity of malaria in any particular situation.

I may here remark that *Ague cake*, the name by which enlarged spleen is commonly known to the country people in the fenny districts of England, is a happy translation of *Tup tillee*,* the words used by the up-country Indian peasants to express the same disease.

Although the intimate connexion between malarious fevers, and organic disease of the spleen is established beyond a doubt, it never was supposed that these diseases bear an *exact* proportion to each other, or that the number of enlarged spleens in any particular situation, should correspond precisely with the number

* Literally, fever spleen.

of attacks of fever suffered by its inhabitants. Many fevers occur, (especially if the attacks have been slight and not often repeated) without being followed by enlargement of the spleen; and many tumid or slightly inflamed spleens become natural in size and structure, soon after the fever has passed off. On the other hand, the spleen may become enlarged from other causes, and in persons who have had no distinctly developed paroxysm of fever, although living in a malarious locality. Such cases, however, are, according to my experience, comparatively very rare.

When I first began to apply this test, I was not aware of its full value. I did not then know the extraordinary susceptibility of the natives, especially the native children of these provinces, to disease of the spleen; nor could I, before trial, have anticipated the facility with which it points out the relative salubrity of different situations, and at once detects unhealthy localities, which could not otherwise be discovered without the experience and observation of several seasons.

It must not, however, be supposed that this disease exists *everywhere* to a considerable extent, among the inhabitants of the North Western Provinces. Places in close proximity, but in otherwise different local circumstances, exhibit the most wonderful differences in this respect; and in some extensive tracts of country, the complaint is scarcely to be met with. On the other hand, it is important to guard against exaggerated notions of the physical condition of the inhabitants of certain situations where so large a proportion are afflicted with this description of organic disease.

Enlargement of the spleen is the least formidable of all organic diseases of the viscera; and is chiefly important as a symbol of another complaint, which generally has preceded, and may come after it. The lesser varieties (marked in the figure O. and S.) and which also form the great mass of the cases registered, may consist with every outward *appearance* of health and vigor. In most places where the disease is common, some strikingly healthy looking men and children were found with decided enlargement of the spleen. But the larger varieties, (M.L.VL.) of which but a comparatively small number are recorded, were usually accompanied with a sickly (cachectic) aspect.

Other diseases besides fever arise from malaria, and other consequences than spleen follow severe and protracted attacks of fever; but most of these can be effectually concealed, and none can be detected with such ease and certainty as enlargement of the spleen. Indeed, without this test, our whole inquiry must have ended in vague and unsatisfactory conjecture, and without a single fact collected among the agricultural population, on which we could depend.

I have no wish to exaggerate the true and legitimate value of the spleen test, nor do I venture to assert that it will indicate the presence of the remote causes of *all fevers*, or even of all pure endemic diseases of this class. There may be different kinds of malaria, giving rise to fevers of different types, and having different complications and consequences; or common continued and typhoid fevers may become mixed up with, and modified by, fevers of local origin. All these are worthy subjects of future inquiry. But from what I have lately witnessed, I am fully persuaded, that it will be found a true and faithful comparative measure of *marsh malaria* in its extended sense; and with *that* alone, have canals and canal irrigation any proper connexion.

It was not, however, until after we had examined the Cantonment of Meerut, that my own faith in the practical utility of the spleen test was fully established. Hitherto, spleen disease had borne some distinct relation to the nearness of water to the surface, and in a few instances where water was *very close*, we had found the almost incredible number of about 70 per cent. of the inhabitants with enlarged spleens. Was the disease then caused by moisture alone, and not always connected with marsh fevers? Meerut seemed well calculated to verify or disprove the received opinion; for in it we had a *known* healthy locality, with water only about 12 feet from the surface.

Four separate observations were made in different parts of that large station, and out of 160 native residents examined, only 3 cases of spleen were found; none above average size.

The city of Delhie appears, at first sight, an instance in which the test failed; but on careful examination, I think it will only be found to furnish a striking confirmation of its general accuracy. The medical topography of the City, Civil Station, and Military Cantonment of Delhie, is an extremely complicated subject, and involves a great variety of important considerations, but I need only briefly notice in this place the following particulars.

Within the walls, and especially in the most dense and crowded quarters of the city, there were comparatively few indications of pure malarious disease. This accords with what has often been remarked in other countries, viz. That the high walls, and narrow crowded smoky streets of large cities, are frequently a safe-guard against marsh miasma, although other causes of disease may abound in such situations.

In the Cantonment Bazar, and suburbs outside the walls, a considerable amount of spleen disease was found. But when we proceeded to examine the vil-

lages situated on the verge of the low moist "khadir" land, immediately in front of the old sapper lines, (a position now abandoned in consequence of its extreme insalubrity) the test at once pointed out malaria in its *highest intensity*.

(Signed) T. E. DEMPSTER, *Surgeon*,

1st Brigade Horse Artillery,

Member of Committee.

APPENDIX C.

Particular account of the manner of conducting the medical examinations.

It is for many reasons of great importance, that I should particularly describe the manner in which the spleen examinations have been conducted.

At each place 20 children and 20 male adults were selected, our chief care being, to take a *fair sample*, not of the sick, but of the "going about" population of the town or village under inspection. The avowedly diseased were discouraged from coming forward, and when brought were rejected, unless there were not others sufficient to make up the required number. We took subjects from all castes, and, whenever it was practicable, examined a certain number of the agricultural laborers found in the adjoining fields, before entering the village, where our numbers were completed from other classes. Each adult was asked his caste, if he had had fever this year, last year, or the year before last. The children were only questioned as to caste. Major Baker generally pointed out the subjects. I conducted the medical examination, and Major Baker entered the result in his note-book.

As the great object was to make use of an unequivocal, but easily applied test, no case was ever registered as "spleen," *unless I had so distinctly felt the enlarged organ that it could not be confounded with any other disease.* When the abdomen was natural and the muscles soft and yielding, a satisfactory examination was generally obtained in the erect position; but if the belly was rigid, and the region of the spleen tumid, but not clearly defined, the subject was put flat on his back, with the knees bent and raised. If an enlarged spleen was not discovered after a *moderately careful* examination so conducted, the person was registered as *free from the disease.* Sometimes, though rarely, really doubtful cases were met with, which could not at once be pronounced upon; these were put aside, and others examined in their stead.

It will be obvious to medical men, that if all our subjects had been examined in a variety of postures, and in various states of the stomach and bowels, several cases of spleen would have been detected, which necessarily escaped my notice. But then this test would no longer have been an *easily applied* one, besides occupying a far longer time than we could afford to bestow on each village. The disease is not only so common, but in general so easily detected after a little practice, that we could afford to sink all cases not easily found, and as *precisely the same*

mode of examination was followed everywhere, it everywhere furnished a fair scale of comparison.

One-half of the subjects selected for examination, was in all practicable cases composed of children under the age of puberty, 1st, because I believed young persons to be more liable to enlargement of the spleen than adults, and 2ndly, because the disease, when present, is in them, more easily and certainly detected. For both these reasons, I considered children to be the more delicate test of malaria. The results amply confirm this opinion.

As the size to which the spleen attains is a very important feature of the disease, and most probably indicative of the intensity of the remote cause, I adopted a simple plan of noting 5 different degrees of size, which will be at once understood by reference to the annexed figure.

O. Signifies a distinctly marked case of spleen.

M. One decidedly larger than O, and the mean between the five varieties.

L. A large spleen extending to, or near to the navel.

VL. A very large one passing across the medial line.

S. A small but perfectly marked case of the disease.

The soft enlargements were seldom registered, even when they presented themselves. I was generally obliged to put them aside among the " doubtful cases ;" for although very confident, as to the real nature of the disease, a mistake was possible. But when I felt a solid tumour in the left side, distinctly ascertained its shape, consistence, and the direction of its edge, and hence knew that such could only be an enlarged spleen, in so registering it, we recorded a *fact*, not a mere medical *opinion*, resting of course on the credibility of the witness.

The very large spleens sometimes met with in bad localities, were rarely admitted into our returns, because the subjects usually presented themselves as " volunteers," and according to the rule adopted, were rejected.

(Signed) T. E. DEMPSTER, *Surgeon,*
1st Brigade Horse Artillery,
Member of Committee.

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vol iii

APPEN

ABSTRACT shewing the comparative salubrity of seven different Military

Years.	Native Troops.													
	Loodiana.		Kurnaul.		Hansi.		Delhi.		Meerut.		Muttra.			
	Per centage of admissions.	Ditto deaths.	Ditto admissions.	Ditto deaths.	Ditto admissions.	Ditto deaths.	Ditto admissions.	Ditto deaths.	Ditto admissions.	Ditto deaths.	Ditto admissions.	Ditto deaths.		
1825	0	0	0	0 . 00	0	0 . 00	0	0 . 00	25	0 1/3 . 33	28	0 3-10th		
1826	13	0 1/3	23	0 1-5th	25	0 1/3 . 33	61	0 5-6th	38	1 2/3 . 66	0	0		
1827	21	0 3-5th	30	0 1/3 . 33	32	0 1/2 . 50	55	1 . 00	49	1 . 00	33	0 6-10th		
1828	24	0 1-6th	29	0 1/3 . 33	45	0 1/3 . 33	45	0 1/2 . 50	24	0 1-5th	23	0 3-10th		
1829	65	0 4-5th	48	0 2/3 . 66	137	1 3/4 . 75	123	1 2/3 . 66	52	0 1/2 . 50	0	0 . 00		
1830	42	0 1/3	45	0 2-5th	84	0 3/4 . 75	113	1 1-5th	52	0 1/4 . 25	0	0 .		
1831	37	0 2-5th	44	0 2-5th	39	0 1/2 . 50	77	0 4-5th	41	0 1/3 . 33	52	0 8-10th		
1832	37	0 3-5th	69	0 3/4 . 75	24	0 1-10th	41	0 1/3 . 33	41	0 3/8 . 37	36	0 4-10th		
1833	17	0 1/2	46	0 2-8th	48	1 2/3 . 66	62	0 2/3 . 66	31	0 2-5th	32	0 9-10th		
1834	46	0 1-5th	39	0 1-5th	142	1 1/2 . 50	41	0 3/4 . 75	27	0 1/3 . 33	46	0 9-10th		
1835	58	0 1/3	84	1 3/4 . 75	57	0 1/4 . 25	72	1 . 00	55	0 4-9th	60	0 7-10th		
1836	39	0 1/2	55	0 2/3 . 66	44	0 1-12th	61	0 1/2 . 50	56	0 4-5th	46	0 7-10th		
1837	46	0 3-5th	67	1 . 00	181	1 5-6th	63	0 2/3 . 66	44	0 1/2 . 50	23	0 4-10th		
1838	55	1 1/4	93	1 1-10th	162	1 1-6th	71	1 . 00	52	0 5-9th	66	3 1-10th		
1839	47	0 1/3	54	0 2/3 . 66	160	0 1/2 . 50	72	0 3-5th	49	0 3-5th	44	0 4-10th		
1840	47	0 1/2	43	0 2/3 . 66	185	0 1/3 . 33	57	0 3-7th	36	0 3/8 . 37	84	0 4-10th		
1841	67	1	84	1 1/4 . 25	264	1 1-5th	157	1 1-9th	69	1 . 00	27	0 3-10th		
1842	82	1	115	1 1-8th	119	0 4-5th	293	1 2/3 . 66	149	1 1-9th	41	0		
1843	91	2 3/4	0	0 . 00	111	1 1/8 . 12	377	3 . 00	116	1 . 00	101	3		
1844	141	2 1-7th	0	0 . 00	93	1 . 00	342	3 1/2 . 60	115	1 1-8th	62	0 6-10th		

The above table is compiled chiefly from returns furnished by the Medical Board.

head of that station, have been extracted from a printed Table by Dr. John Murray.

inaccurate.

DIX D.

Stations in the NORTH WESTERN PROVINCES, from 1825 *to* 1844.

EUROPEAN TROOPS.

AGRA.		LOODIANA.		KURNAUL.		MEERUT.		MUTTRA.		AGRA.		
Per centage of admissions.	*Ditto deaths.*	*Ditto admissions.*	*Ditto deaths.*	*Ditto admissions.*	*Ditto deaths.*	*Ditto admissions.*	*Ditto deaths.*	*Ditto admissions.*	*Ditto deaths.*	*Ditto admissions.*	*Ditto deaths.*	
42	4 2-5th	0	0	0	0·00	107	2¼ ·25	14	0	335	2 9-10th	2·90
0	0 ·40	0	0	76	14¼ ·25	112	2⅔ ·66	0	0	0	0	0·00
31	1 ·00	0	0	148	3¾ ·75	206	3 1-5th	175	4¾ ·75	235	4 4-5th	4·80
15	0¼ ·25	0	0	140	3¼ ·25	175	3½ ·50	115	1 1-10th	228	2 7-10th	2·70
0	0 ·00	0	0	198	3½ ·50	152	3 1-5th	0	0 ·00	0	0	0·00
0	0 ·00	0	0	140	2½ ·50	145	2½ ·50	0	0 ·00	0	0	0·00
40	0½ ·50	0	0	130	2¾ ·75	118	3 ·00	161	2 9-10th	144	3	3·00
46	0⅔ ·66	0	0	136	3 2-5th	94	3½ ·50	75	0 ·00	102	1 5-9th	1·55
56	0⅞ ·87	0	0	68	2 5-6th	78	1 5-6th	82	6 ·00	112	2⅛	2·12
59	0⅔ ·66	0	0	60	3 ·00	88	2¼ ·25	86	11 ·00	109	1⅔	1·66
78	1 4-7th	0	0	64	1½ ·50	78	2⅔ ·66	88	0 ·00	124	1 1-9th	1·11
36	0 5-6th	0	0	130	1⅔ ·66	97	4 ·00	142	4 7-10th	126	2½	1·50
69	1¼ ·25	0	0	157	2 3-10th	75	1 3-7th	82	0 9-10th	116	4	4·00
173	5¾ ·75	0	0	201	7¼ ·25	121	4⅓ ·33	176	11½ ·50	225	7½	7·50
92	1¼ ·25	100	2 2-5th	171	5 ·00	138	2 5-7th	129	8¾ ·75	159	5⅓	5·33
125	1½ ·50	94	3½ ·50	152	3 2-5th	113	2¼ ·25	99	1 ·00	151	3	3·00
79	1 3-5th	109	1 4-5th	272	7¾ ·75	172	3½ ·50	146	1 1-10th	118	1 7-10th	1·70
144	1 1-10th	149	4⅓ ·33	309	9¼ ·25	346	3 3-5th	69	1 ·00	110	1 3-5th	1·60
87	1⅔ ·66	185	3⅔ ·66	0	0 ·00	293	4 ·00	124	6¾ ·75	141	5 3-5th	5·60
99	1 3-5th	189	3 1-5th	0	0·00	307	3 3-5th	124	1 9-10th	125	3 3-10th	3·30
	·60		·20				·60		·90			

Those for Kurnaul having been returned for correction,* the few entries made under the
The returns for Meerut and Delhi for the years 1842, 1843 and 1844, are stated to be

(Signed) W. E. BAKER, *Major, Engineers,*
President.

(Signed) T. E. DEMPSTER, *Surgeon,*
Member.

* Subsequently received, and the deficiencies supplied except for the year 1843, which is still incomplete.

ABSTRACT of Medical Examinations of 26 *Irrigating Villages*

Villages.	Children of all Classes.		Adults.															
			Brahmins, Fukeers, &c.		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunnias.*		*Artisans, &c., &c.*		*Menials.*		*Totals.*	
	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Hansi, ...	36	24	0	0	8	0	8	4	6	4	18	6	3	3	43	17
Hissar, ...	17	23	4	0	8	2	9	0	5	1	6	4	1	0	33	7
Khurrur, ...	16	4	1	0	15	2	0	0	0	0	0	0	2	0	18	2
Raipoor, ...	10	10	0	0	13	7	0	0	0	0	0	0	0	0	13	7
Satrouda, ...	11	9	3	0	11	3	0	0	0	0	0	0	2	1	16	4
Sulems Thekopoor, ...	8	12	0	0	4	4	5	4	0	0	1	1	1	0	11	9
Shahpoor, ...	4	16	0	0	12	2	0	0	0	1	1	2	2	0	15	5
Matursham, ...	11	9	5	1	10	2	0	0	0	0	2	0	0	0	17	3
Mingnee Khera, ...	8	12	0	0	4	1	6	2	5	0	1	0	1	0	17	3
Sulemgurh, ...	10	10	2	1	4	3	2	1	1	0	0	1	3	2	12	8
Kabrere, ...	9	11	0	0	8	1	4	0	0	2	0	0	4	1	16	4
Siswal, ...	8	12	1	0	8	2	0	0	2	1	2	1	3	0	16	4
Kheree, ...	11	9	2	1	8	5	0	0	1	0	1	2	0	0	12	8
Majra, ...	5	15	2	2	2	7	1	0	0	1	1	1	2	1	8	12
Narnound, ...	12	8	0	0	12	2	0	0	4	0	1	0	0	2	16	4
Rajthul, ...	12	8	0	0	11	6	1	1	0	0	1	0	0	0	13	7
Ramra, ...	13	7	12	2	0	0	0	0	0	2	2	0	2	0	16	4
Jheend, ...	28	12	7	3	6	4	2	0	8	0	5	4	1	0	29	11
Kokhree, ...	12	8	2	0	10	4	0	0	0	0	2	0	2	0	16	4
Bohutwala, ...	8	12	1	1	9	5	0	0	1	0	0	1	0	2	11	9
Dhatrut, ...	8	12	2	0	5	2	5	0	4	0	1	1	0	0	17	3
Jamunee, ...	9	11	4	1	6	3	0	0	0	1	3	2	0	0	13	7
Rujana, ...	11	9	6	3	5	4	0	0	1	0	0	0	0	1	12	8
Suffeedhun, ...	15	5	2	1	0	0	9	2	4	0	0	1	0	1	15	5
Baroude, ...	5	8	0	0	0	0	9	5	2	0	1	0	1	2	13	7
Josshee, ...	3	17	1	2	11	3	0	0	0	1	1	0	1	0	14	6
	300	293	57	18	190	74	61	19	44	14	49	27	31	16	432	168

situated within half a mile of the Hansi branch of the Western Jumna Canals.

Per centage of adults having suffered from fever in			*Per centage of enlarged spleens.*	*Depth of water below the surface of ground.*	*Annual average amount of canal irrigation.*			*Average annual amount of irrigated rice.*	*Detail of size of enlarged spleens.*					
					Tor.	Daul.	Total.							
1844	1845	1846		Feet.	Beegas.	Beegas.	Beegas.	Beegas.	VL	L	M	O	S	Total.
43	33	20	34	55	5270	250	5520	700	1	4	3	21	12	41
22	22	12	37	81	580	1000	1580	0	0	3	5	17	5	30
45	20	5	15	84	940	160	1100	120	0	0	0	4	2	6
55	10	35	42	96	350	200	550	75	0	0	2	11	4	17
45	50	30	32	95	25	125	150	0	0	0	1	8	4	13
45	65	20	52	0	25	125	150	0	0	1	4	15	1	21
60	65	15	52	0	325	50	375	0	0	0	3	14	4	21
65	35	10	30	0	345	80	425	5	0	0	1	6	5	12
55	40	30	37	0	325	75	400	10	0	0	1	7	7	15
70	60	15	45	30	725	75	800	25	0	1	4	11	2	18
55	50	15	37	0	650	50	700	50	0	1	0	5	9	15
55	50	10	40	72	1130	170	1300	0	0	0	2	10	4	16
50	55	30	42	60	775	25	800	150	0	2	3	7	5	17
75	60	25	67	0	1595	25	1620	295	0	0	4	14	9	27
75	50	30	30	107	3350	50	3400	700	0	3	5	3	1	12
45	40	20	37	0	200	350	550	20	0	1	5	7	2	15
35	20	10	27	145	200	350	550	20	0	0	0	6	5	11
30	25	20	29	0	1400	500	1900	450	0	0	4	9	10	23
45	15	15	30	0	400	150	550	160	0	0	1	6	5	12
75	75	70	52	0	825	125	950	240	0	2	4	14	1	21
35	25	10	37	145	1775	125	1900	500	0	0	0	9	6	15
70	60	20	45	145	775	175	950	260	0	0	4	9	5	18
50	30	30	42	0	1075	175	1250	370	0	1	3	9	4	17
30	35	50	25	139	425	175	600	125	0	0	0	7	3	10
30	45	25	45	0	330	20	350	60	0	0	3	10	2	15
45	40	10	57	36	725	175	900	150	1	0	4	13	5	23
50	41	22	39	92	-	-	-	-	-	-	-	-	-	-

2 2 2 2 2 3½ 3½ 3½ 3½ 1½ 1 1 1 1 2½

24
24
5-2
8½
58½-10½

ABSTRACT of Medical Examinations of 5 Irrigating villages situate

Villages.	*Children of all Classes.*		Adults.									
			Brahmins, Fukeers, &c.		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunnias.*		*Artisans, &c.*	
	N	E	N	E	N	E	N	E	N	E	N	E
Nianna, ...	18	2	2	0	11	0	1	0	1	0	1	0
Akburpoor Nowlee, ..	17	3	0	0	13	2	0	0	1	1	1	0
Booreana, ...	12	8	0	0	15	2	0	0	0	0	0	1
Ameerpoor Bheinee, ..	9	11	3	0	14	1	0	0	0	0	0	0
Dalimwala, ...	16	4	1	0	15	0	0	0	2	0	1	0
	72	28	6	0	68	5	1	0	4	1	3	1

half a mile or more from the Hansi branch of the Western Jumna Canals.

Adults.																				
Menials, &c.		*Totals.*		*Per centage of adults having suffered from fever in*			*Per centage of enlarged spleens.*	*Depth of water below the surface of ground.*	*Annual average amount of canal irrigation.*			*Average annual amount of irrigated rice.*	*Detail of sizes of enlarged spleens.*							
N	E	N	E	1844	1845	1846		Feet.	Tor. Beegas.	Daul. Beegas.	Total. Beegas.	Beegas.	VL	L	M	O	S	Total.
4	0	20	0	15	15	10	5	106	275	100	375	20	0	0	0	0	2	2
2	0	17	3	75	40	20	15	0	90	10	100	0	0	0	0	3	3	6
1	1	16	4	40	45	25	30	117	not known	not known	not known	0	0	0	0	6	6	12
2	0	19	1	80	20	20	30	124	1480	20	1500	225	0	0	1	7	4	12
1	0	20	0	30	35	5	10	127	510	100	610	110	0	0	0	3	1	4
10	1	92	8	40	31	16	18	118										

7 - ½ - 2 2 2 2 3 3 - - - 2 1 - - 3

ABSTRACT of Medical Examinations of 7 Irrigating villages distant half

Villages.	Children of all Classes.		Adults.									
			Brahmins, Fukeers, &c.		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunnias.*		*Artisans, &c.*	
	N	E	N	E	N	E	N	E	N	E	N	E
Chota Oorlana, ...	11	9	0	0	0	0	14	2	0	0	2	0
Burra Oorlana, ...	11	9	2	0	1	0	14	0	1	0	0	0
Seenk, ...	17	3	0	0	13	4	0	0	1	0	0	0
Burra Anchura, ...	15	5	7	0	7	0	0	0	2	0	2	1
Gungana, ...	17	3	5	0	8	1	0	0	1	0	3	0
Bootana,..	19	1	2	0	12	2	0	0	2	0	0	0
Barouda,..	19	1	0	0	11	0	1	0	1	1	5	1
	109	31	16	0	52	7	29	2	8	1	12	2

a mile or more from the Bootana branch of the Western Jumna Canals.

Adults.																		
Menials.		*Totals.*		*Per centage of adults having suffered from fever in*			*Per centage of enlarged spleens.*	*Depth of water below the surface of ground.*	*Annual average amount of canal irrigation.*			*Average annual amount of irrigated rice.*	*Detail of sizes of enlarged spleens.*					
									Tor.	Daul.	Total.							
N	E	N	E	1844	1845	1846		Feet.	Beegas.	Beegas.	Beegas.	Beegas.	VL	L	M	O	S	Total.
1	1	17	3	45	40	25	30	0	475	25	500	100	0	0	0	8	4	12
2	0	20	0	45	55	40	22	106	1300	150	1450	200	0	0	2	2	5	9
0	2	14	6	50	30	20	22	109	1800	150	1950	260	0	0	0	6	3	9
1	0	19	1	50	25	20	15	138	745	5	750	20	0	0	0	5	1	6
2	0	19	1	20	15	20	10	99	2025	50	2075	80	0	0	0	4	0	4
2	0	18	2	60	60	30	7	82	3430	50	3480	500	0	0	0	3	0	3
0	0	18	2	20	30	0	7	78	4500	50	4550	20	0	0	0	1	2	3
8	3	125	15	41	36	22	16	102										

ABSTRACT of Medical Examinations of 22 *Villages situated*

Situation.	Villages.	Children of all classes.		Adults.									
				Brahmins, Fukeers, &c.		*Hindoo Cultivators.*		*Mussulman Cultivators.*		*Bunnias.*			
		N	E	N	E	N	E	N	E	N	E		
Nujufgurh Jheels.	Runhowla, ...	9	11	2	1	10	2	0	0	0			
	Baprowla, ...	11	9	1	2	8	4	0	0	1			
	Nujufgurh, ...	17	3	2	2	0	0	4	0	4			
	Nugla, ...	2	18	0	2	8	5	0	0	0			
	Pandwala, ...	4	16	2	7	3	6	0	0	0			
	Oojwa, ...	8	12	0	1	9	2	1	2	1			
	Shumushpoor, ...	4	16	0	0	11	7	0	0	0			
	Isheepoor, ...	19	1	2	0	9	4	0	0	3			
	Badlee, ...	11	9	2	0	7	0	0	0	2			
Jumna West Khadir.	Duheerpoor, ...	3	17	0	3	7	5	0	0	0			
	Indurput, ...	18	7	4	0	7	1	2	0	1			
	Newul, ...	8	12	0	1	0	0	7	8	0			
	Mogul Majra, ...	7	13	1	1	6	1	3	2	0			
Jumna East Khadir.	Luknowtee, ...	10	10	1	0	1	0	2	0	2			
	Soorajpoor, ...	7	13	0	1	2	1	9	3	0			
	Shahdera, ...	11	9	1	1	3	1	3	1	3			
	Joondla, ...	4	16	6	1	9	3	0	0	0			
Valley of the Hindun.	Arthulla, ...	20	0	1	0	3	0	7	1	1			
	Kurrara, ...	14	6	0	0	17	0	0	0	0			
	Ghazeeoodeennuggur, .	14	6	4	0	0	0	5	1	6			
	Gokuna, ...	14	6	0	0	10	2	0	0	0			
	Ghorao, ...	13	7	5	0	1	0	4	0	1			
		223	217	34	23	131	44	47	18	25	8		

near the Nujufgurh Jheels or in the Khadir lands of Rivers.

Adults.																	
Artisans, &c.		*Menials, &c.*		*Totals.*		*Per centage of adults having suffered from fever in*			*Per centage of enlarged spleens.*	*Depth of water below surface of ground.*	*Detail of sizes of enlarged spleens.*						
N	E	N	E	N	E	1844	1845	1846		Feet.	V L	L	M	O	S	Total.
0	1	4	0	16	4	70	45	30	37	17	0	0	3	7	5	15
3	0	0	1	13	7	55	70	40	40	15	0	0	0	8	8	16
4	2	0	6	14	6	25	45	70	22	19	0	0	0	8	1	9
2	2	1	0	11	9	65	75	60	67	10	0	0	0	19	8	27
0	2	0	0	5	15	45	60	85	77	5	0	4	7	16	4	31
1	0	1	2	13	7	25	60	70	47	14	0	1	3	12	3	19
0	0	2	0	13	7	35	90	65	57	7	0	1	2	16	4	23
1	0	1	0	16	4	15	25	50	12	27	0	0	0	4	1	5
3	3	1	1	15	5	45	65	40	35	20	0	0	1	6	7	14
0	0	1	2	8	12	50	25	25	72	7	0	3	3	16	7	29
2	0	1	2	17	3	55	40	50	25	10	0	0	0	3	7	10
2	0	2	0	11	9	50	45	20	52	14	0	0	3	15	3	21
1	0	4	0	15	5	40	60	20	45	10	0	1	3	10	4	18
6	0	5	2	17	3	55	45	15	32	18	0	0	0	9	4	13
1	3	0	0	12	8	35	40	25	52	10	0	0	2	12	7	21
3	2	0	1	13	7	65	60	40	40	15	0	2	3	8	3	16
0	0	1	0	16	4	40	40	25	50	8	0	0	0	7	13	20
6	0	1	0	19	1	15	25	30	2	12	0	0	0	0	1	1
2	0	1	0	20	0	20	20	10	15	14	0	0	0	1	5	6
0	1	3	0	18	2	70	45	45	20	38	0	0	0	2	6	8
2	0	2	0	14	2	69	81	69	22	13	0	0	0	5	3	8
4	1	4	0	19	1	35	25	30	20	17	0	0	1	4	3	8
43	17	35	11	315	121	44	49	42	38	15						

ABSTRACT of Medical Examinations of 22 villages situated within

Villages.	Children of all Classes.		Adults.													
			Brahmins, Fukeers, &c., &c.		*Hindoo Cultivators.*		*Mussulman Cultivators.*		*Bunnias.*		*Artisans, &c., &c.*		*Menials.*		*Total of adults.*	
	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Kurnaul, ...	30	50	6	0	12	4	5	4	11	10	19	5	4	0	57	23
Phoorluk, ...	7	13	6	0	5	0	0	1	0	5	1	0	1	1	13	7
Raipoor, ...	6	14	3	1	6	2	1	0	2	0	4	1	0	0	16	4
Dhurmgurh, ...	5	15	0	4	10	2	0	0	0	0	2	2	0	0	12	8
Shera, ...	5	15	1	1	9	7	0	0	1	0	0	0	0	1	11	9
Mudlowda, ...	8	12	2	0	7	7	0	0	1	0	1	0	1	1	12	8
Kokrana, ...	11	9	0	0	5	5	0	0	1	0	2	2	3	2	11	9
Didwaree, ...	1	19	1	0	5	6	2	2	1	1	0	1	0	1	9	11
Chumrara, ...	4	16	2	1	7	4	0	1	0	1	0	1	2	1	11	9
Bullee, ...	8	12	1	2	3	2	1	0	1	2	2	0	2	4	10	10
Mahomedpoor Majra, ..	2	18	1	2	6	4	0	0	2	1	0	2	1	1	10	10
Sitaolee, ...	5	15	0	1	6	6	0	0	2	1	2	2	0	0	10	10
Jooah, ...	3	17	3	1	5	3	0	0	0	3	1	4	0	0	9	11
Jajhee, ...	5	15	4	0	4	6	0	1	0	0	0	3	1	1	9	11
Bhutgong, ...	5	15	1	4	3	8	0	1	0	1	0	1	1	0	5	15
Jhurouth, ...	2	18	2	1	7	5	0	0	1	0	0	3	1	0	11	9
Jutowla, ...	3	17	1	5	3	6	0	0	1	1	1	1	0	1	6	14
Bowanna, ...	3	17	1	1	5	6	1	0	2	2	0	0	1	1	10	10
Hydurpoor, ...	4	16	1	2	4	5	0	0	2	1	1	1	2	1	10	10
Subzee Mundee, ...	10	10	0	0	5	1	0	0	2	2	7	3	0	0	14	6
Rohilla Khan Serai, ..	8	12	2	1	2	1	3	2	1	0	5	2	0	1	13	7
Delhi,*	60	20	3	0	5	0	0	0	28	3	33	3	2	3	71	9
	195	365	41	27	124	90	13	12	59	34	81	37	22	20	340	220
* Delhie City, ...	47	13	1	0	5	0	0	0	22	0	25	3	2	2	55	5
Do. Cantonments, ...	13	7	2	0	0	0	0	0	6	3	8	0	0	1	16	4

half a mile of the Delhi branch of the Canals West of Jumna.

Per centage of adults having suffered from fever in			*Per centage of enlarged spleens.*	*Depth of water below the surface of ground.*	*Average annual amount of canal irrigation.*	*Average annual amount of irrigated rice.*	*Proportion of tor irrigation.*	*Proportion of daul irrigation.*	*Detail of sizes of enlarged spleens.*					
1844	1845	1846		Feet.	Beegas.	Beegas.	Beegas.	Beegas.	VL	L	M	O	S	Total.
51	29	14	46	16	4000	1800	3600	400	1	4	12	45	11	73
55	55	45	50	14	1350	175	925	425	0	1	6	10	3	20
40	40	35	45	12	350	125	200	150	0	0	4	11	3	18
70	45	25	57	0	2200	500	1750	450	0	0	4	16	3	23
45	50	15	60	7	3000	750	2600	400	0	1	5	15	3	24
35	45	15	50	14	3130	420	2630	500	0	0	1	13	6	20
60	65	65	45	12	350	50	100	250	0	0	3	10	5	18
60	75	55	75	7	900	300	750	150	0	3	9	12	6	30
15	15	45	62	7	1450	350	1200	250	0	2	6	14	3	25
45	25	40	55	7	1710	300	1410	300	0	1	5	12	4	22
75	55	45	70	9	650	5	150	500	0	0	6	14	8	28
65	45	40	62	7	1100	50	600	500	2	3	7	10	3	25
65	40	25	70	5½	3000	400	2600	400	0	5	8	9	5	27
40	45	55	65	2½	600	150	350	250	1	3	7	13	1	25
35	60	50	75	4	5500	2500	4500	1000	1	2	5	20	2	30
65	65	50	67	5	550	20	475	75	0	0	5	15	7	27
75	25	80	77	5	1050	125	1000	50	0	3	5	18	5	31
55	40	45	67	6½	3000	800	2980	20	1	1	4	14	7	27
60	55	50	65	10	1000	225	1000	0	0	3	2	16	5	26
25	50	40	40	17	1200	10	1150	50	0	1	1	12	2	16
35	45	50	47	20	1000	175	995	5	0	1	2	10	6	19
52	32	29	18	40	—	—	—	—	0	0	3	17	9	29
51	45	41	58	11										
50	27	23	35	41					0	0	0	12	6	18
60	50	45	27	39					0	0	3	5	3	11

2 2 2 3 2 3 7 2½ 2½ 2½ 1½ 1 1 1 2½

ABSTRACT of Medical Examinations of 28 *Irrigating villages distant half*

Villages.	Children of all Classes.		Adults.											
			Brahmins, Fakeers, &c.		*Hindoo Cultivators.*		*Mussulman Cultivators.*		*Bunnias.*		*Artisans, &c.*		*Menials.*	
	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Sitoundi, ...	25	15	9	2	10	0	6	0	5	1	3	1	3	0
Gugseena, ...	33	7	6	0	20	1	0	0	5	0	3	0	4	1
Rair, ...	14	26	1	1	0	1	19	5	2	0	4	4	3	0
Moonuk, ...	27	13	7	0	2	1	11	1	4	3	3	1	4	3
Baul Jaton, ...	2	18	2	5	4	3	0	0	1	1	1	2	1	0
Baolee, ...	7	13	1	2	0	0	9	7	0	0	0	0	1	0
Burra Assun, ...	9	11	2	2	6	0	0	0	4	2	0	0	3	1
Chota Assun, ...	4	16	1	4	10	2	0	0	0	2	1	0	0	0
Noulta, ...	9	11	5	0	6	4	0	0	1	3	1	0	0	0
Duhur, ...	14	6	1	0	7	3	0	0	1	1	2	2	3	0
Hurtaree, ...	8	12	2	0	0	0	8	2	2	0	1	2	2	1
Brahmin Majra, ...	2	18	10	5	0	0	0	0	1	0	1	2	0	1
Burra Joundhun, ...	4	16	3	5	5	5	0	0	0	0	1	1	0	0
Karud, ...	3	17	2	1	7	2	0	0	0	0	3	3	0	2
Issrana, ...	8	12	1	0	5	4	0	0	2	1	2	3	1	1
Bhinjowl, ...	11	9	6	1	6	1	1	0	1	1	0	0	3	0
Dhindar, ...	9	11	3	1	0	0	7	2	1	1	1	1	2	1
Hoolana, ...	11	9	1	2	9	3	0	0	1	1	1	1	1	0
Kurreooree, ...	0	20	2	0	6	7	0	0	0	1	0	3	0	1
Chitana, ...	5	15	1	2	10	2	0	0	1	0	1	0	2	1
Bidhlaun, ...	5	15	1	1	5	3	0	0	1	3	2	1	2	1
Suelana, ...	6	14	2	1	10	0	0	0	2	1	1	1	1	1
Sissana, ...	12	8	4	0	7	1	0	0	2	2	3	0	0	1
Kanduh, ...	9	11	2	2	7	2	0	0	0	3	3	1	0	0
Kutloopoor, ...	8	12	4	0	10	4	0	1	0	0	1	0	0	0
Burra Khera, ...	4	16	1	0	9	8	0	0	0	0	2	0	0	0
Badlee, ...	7	13	4	2	4	1	0	2	1	2	0	3	0	1
Wuzeeorpor, ...	3	17	1	1	6	6	0	0	0	1	0	3	0	2
	259	381	85	40	171	64	61	20	38	30	41	35	36	19

2 10 1½ 1½ 1 ½ 1½ 1 1 1 1½

a mile or more from the Delhie branch of the Canals West of Jumna.

Totals.		*Per centage of adults having suffered from fever in*			*Per centage of enlarged spleens.*	*Annual average amount of canal irrigation.*			*Average annual amount of irrigated rice.*	*Wells.*	*Detail of sizes of enlarged spleens.*					
						Tor.	Daul.	Total.								
N	E	1844	1845	1846		Beegas.	Beegas.	Beegas.	Beegas.	Feet.	VL	L	M	O	S	Total.
36	4	52	42	20	24	400	1000	1400	150	25	0	0	1	9	9	19
38	2	35	17	10	11	1680	1520	3200	200	17	0	0	0	4	5	9
29	11	47	30	5	46	2400	500	2900	900	19	1	2	7	22	5	37
31	9	52	20	17	27	2100	400	2500	950	28	0	0	2	11	9	22
9	11	50	55	40	72	1200	1000	2200	600	0	0	2	7	14	6	29
11	9	75	60	40	55	2000	300	2300	1100	10	0	3	9	7	3	22
15	5	35	25	45	40	950	150	1100	200	7	0	1	3	5	7	16
12	8	70	65	45	60	550	50	600	80	8	0	1	4	11	8	24
13	7	65	55	45	45	2900	1200	4100	100	9	1	2	3	7	5	18
14	6	30	40	40	30	850	100	950	150	33	0	0	0	8	4	12
15	5	55	55	50	42	500	50	550	40	18	0	1	0	9	7	17
12	8	45	65	55	65	950	50	1000	10	16	1	0	4	20	1	26
9	11	55	40	45	67	1000	100	1100	50	20	0	0	6	12	9	27
12	8	55	65	30	62	1115	10	1125	5	30	0	0	3	13	9	25
11	9	50	40	55	52	2030	20	2050	75	0	1	0	2	13	5	21
17	3	50	75	40	30	720	5	725	40	14	0	0	2	9	1	12
14	6	55	40	60	42	375	100	475	20	17	0	0	1	13	3	17
13	7	65	50	45	40	700	800	1500	150	15	0	0	2	5	9	16
8	12	80	70	45	80	650	50	700	50	5	1	0	11	18	2	32
15	5	30	30	55	50	680	20	700	5	12	0	0	1	12	7	20
11	9	50	40	5	60	1980	20	2000	0	15	1	1	2	17	3	24
16	4	40	50	10	45	2000	0	2000	0	33	0	0	1	13	4	18
16	4	45	40	30	30	2750	50	2800	150	40	0	0	2	7	3	12
12	8	40	40	40	47	2595	5	2600	20	18	0	1	5	12	1	19
15	5	45	55	65	42	200	50	050	0	19	1	1	1	11	3	17
12	8	80	85	75	60	2800	0	2800	400	9	0	1	4	14	5	24
12	8	80	85	75	60	1200	0	1200	200	8	0	3	2	14	5	24
9	11	30	65	65	60	1200	0	1200	200	8	0	0	2	3	19	6	30
7	13	60	70	45	75	1140	10	1150	175	0						
432	208	51	49	40	49					18						

ABSTRACT of Medical Examinations of 9 *Irrigating villages* situated

Villages.	Children of all Classes.		Adults.															
			Brahmins, Fakeers, &c., &c.,		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunnias.*		*Artisans, &c., &c.,*		*Menials.*		*Totals.*	
	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Singpoora, ...	11	9	3	1	8	3	0	0	1	0	1	0	2	1	15	5		
Chichrana, ...	9	11	1	0	9	5	0	0	1	1	2	1	0	0	13	7		
Bhynswal, ...	10	10	3	0	9	0	0	0	0	1	3	2	1	1	16	4		
Mahura, ...	9	11	1	0	9	4	0	0	1	1	2	0	1	1	14	6		
Gohanna, ...	6	14	0	0	0	0	1	2	6	2	5	4	0	0	12	8		
Muhmoodpoor, ...	7	13	0	0	11	6	0	0	1	0	0	0	2	0	14	6		
Sumanka, ...	5	15	3	2	4	7	0	0	1	0	0	0	1	2	9	11		
Korana, ...	12	8	5	0	9	1	0	0	0	2	2	1	0	0	16	4		
Uhur, ...	9	11	4	2	7	1	0	0	0	1	2	0	2	1	15	5		
	78	102	20	5	66	27	1	2	11	8	17	8	9	6	124	56		
10	1½	1½	1	1	1½	1	1	1	1	1	1	1	1	1	1½	1½		

within half a mile of the Rohtuk branch of the Canals West of the Jumna.

Per centage of adults having suffered from fever in			*Per centage of enlarged spleens.*	*Depth of water below the surface of ground.*	*Annual average amount of canal irrigation.*			*Average annual amount of irrigated rice.*	*Detail of sizes of enlarged spleens.*					
					Tor.	Daul.	Total.							
1844	1845	1846		Feet.	Beegas.	Beegas.	Beegas.	Beegas.	VL	L	M	O	S	Total.
50	70	45	35	52	150	0	150	0	0	0	1	7	6	14
60	40	20	45	18	1750	50	1800	50	1	0	1	8	8	18
20	15	35	35	0	1400	100	1500	150	0	1	4	3	6	14
45	40	20	42	50	1050	150	1200	125	0	0	3	8	6	17
40	30	20	55	55	1550	50	1600	300	0	1	4	11	6	22
75	40	25	47	6	3740	10	3750	425	0	0	4	8	7	19
40	35	25	65	8	1185	15	1200	125	1	2	5	11	7	26
45	25	25	30	16	4420	200	4620	700	0	0	1	9	2	12
45	50	30	40	24	2050	300	2350	250	0	0	2	9	5	16
47	38	27	44	28										

ABSTRACT of Medical Examinations of 6 *Irrigating villages distant half*

Villages.	Children of all Classes.		Adults.													
			Brahmins, Fukeers, &c., &c.,		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunnias.*		*Artisans, &c.*		*Menials.*		*Total.*	
	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Rohtuk, ...	17	3	2	0	4	0	1	0	8	0	4	0	1	0	20	0
Chumaree, ...	10	10	0	1	9	3	0	0	3	0	2	0	2	0	16	4
Sanghee, ...	11	9	2	0	14	0	0	0	2	1	1	0	0	0	19	1
Burra Guhlowr, ..	13	7	2	1	12	2	0	0	1	0	0	0	1	1	16	4
Chota Guhlowr, ..	11	9	9	7	0	0	0	0	0	0	0	0	2	2	11	9
Matun, ...	9	11	1	0	10	3	0	0	3	0	1	0	1	1	16	4
	71	49	16	9	49	8	1	0	17	1	8	0	7	4	98	22

2

a mile or more from the Rohtuk branch of the Western Jumna Canals.

Per centage of adults having suffered from fever in			*Per centage of enlarged spleens.*	*Depth of water below the surface of ground.*	*Annual average amount of canal irrigation.*			*Average annual amount of irrigated rice.*	*Detail of sizes of enlarged spleens.*					
					Tor.	Daul.	Total.							
1844	1845	1846		Feet.	Beegas.	Beegas.	Beegas.	Beegas.	VL	L	M	O	S	Total.
5	20	40	7	72	750	0	750	0	0	0	0	0	3	3
45	65	45	35	50	650	100	750	0	0	0	0	6	8	14
65	45	15	25	28	3000	50	3050	150	0	0	2	5	3	10
35	30	25	27	46	745	5	750	20	0	0	0	4	7	11
30	25	5	45	46	500	0	500	10	0	0	1	11	6	18
25	20	30	37	47	1210	20	1230	150	0	0	5	9	1	15
34	34	27	29	48										

ABSTRACT of Medical Examinations of 24

Collectorate.	Villages.	Children of all Classes.		Adults.			
				Brahmins, Fukeers, &c.		*Hindoo cultivators.*	
		N	E	N	E	N	E
Rohtuk, ..	Barouta, ...	16	4	4	3	7	1
	Gorur, ...	14	6	2	0	5	0
	Booketuh, ...	16	4	1	0	12	3
	Poolungee, ...	18	2	8	0	6	0
	Jusrana, ...	16	4	3	0	12	1
	Guewana, ...	14	6	6	0	6	0
	Kuelooee, ...	20	0	1	0	7	0
	Roorkhi, ...	17	3	2	0	4	0
	Moongan, ...	15	5	3	0	9	2
	Goyla, ...	20	0	1	0	14	0
	Doolhera, ...	19	1	2	0	10	0
	Matin, ...	19	1	2	1	9	1
	Assueenda, ...	19	1	3	0	11	2
	Khoorawar, ...	17	3	3	1	8	2
	Kheree Sadh, ...	18	2	2	1	10	0
	Ruhundana, ...	18	2	2	0	7	0
	Jowlana, ...	18	2	5	0	7	
Hissar, ..	Burchuppur, ...	14	6	3	1	9	1
	Mohula, ...	15	5	2	0	9	1
	Bass, ...	20	0	3	0	10	1
	Bhatowl, ...	18	2	8	1	7	0
	Bugla, ...	17	3	1	0	16	0
	Jakhode, ...	18	2	1	0	9	0
	Myerr, ...	14	6	1	0	12	3
		410	70	69	8	216	18

unirrigated villages in the Delhi Territory.

| Adults. | | |

ABSTRACT of Medical Examinations of 21 *towns and villages in the Protected*

Situation.	Villages.	Children of all Classes.		Adults.					
				Brahmins, Fukeers, &c.		*Hindoo cultivators.*		*Mussulman cultivators.*	
		N	E	N	E	N	E	N	E
Situated near the Delhi Canal.	Dadoopoor, ...	10	9	0	0	7	2	0	0
	Boorreea, ...	13	7	4	0	2	0	1	1
	Moonda Majra, ...	14	6	3	1	5	3	0	0
	Damla, ...	10	10	1	0	9	1	3	0
	Kanjnoon, ...	6	14	1	0	8	5	0	0
	Rudowr, ...	8	12	3	0	0	0	0	0
	Zynpoor, ...	4	16	0	2	3	1	3	1
	Indree, ...	5	15	4	1	3	1	1	0
	Gooda, ...	5	15	3	2	2	1	2	3
	Khera, ...	8	12	2	2	3	3	2	0
	Beebeepoor, ...	8	12	1	1	12	2	0	0
	Dhurrur, ...	8	12	1	0	0	0	9	2
		99	140	23	9	54	19	21	7
Unconnected with the Delhi Canal.	Loodiana, ...	12	8	1	0	0	1	0	0
	Umballa, ...	19	1	0	0	4	0	5	2
	Khooda, ...	10	10	6	0	2	0	2	2
	Mullana, ...	11	9	5	2	5	0	3	0
	Mustafabad, ...	9	11	5	0	0	0	2	1
	Tejlee, ...	14	6	4	1	9	0	0	0
	Bun, ...	11	9	1	1	5	1	0	0
	Ladwa, ...	12	8	1	1	1	1	1	0
	Pinjokra, ...	7	13	0	0	7	2	0	1
		105	75	23	5	33	5	13	6

Sikh States, of which 12 *are connected, and* 9 *unconnected with the Delhi Canal.*

Bunnias.		Artisans, &c.		Menials, &c.		Totals.		Per centage of adults having suffered from fever in			Per centage of enlarged spleens.	Depth of water below the surface of ground.	Detail of sizes of enlarged spleens.					
N	E	N	E	N	E	N	E	1844	1845	1846		Feet.	VL	L	M	O	S	Total.
2	1	5	1	1	0	15	4	45	55	40	34	12	0	1	2	6	4	13
6	1	3	0	2	0	18	2	30	50	20	22	0	0	1	0	6	2	9
1	2	3	1	1	0	13	7	60	65	20	32	0	0	0	0	10	3	13
4	0	1	0	1	0	19	1	35	70	30	27	0	0	0	0	4	7	11
1	1	2	2	0	0	12	8	60	60	40	55	0	0	2	3	13	4	22
7	5	3	0	0	2	13	7	35	70	25	47	24	0	1	1	12	5	19
3	2	0	3	1	1	10	10	55	55	20	65	0	1	1	1	19	4	26
2	3	1	4	0	0	11	9	60	40	35	60	15	1	2	4	13	4	24
1	0	3	3	0	0	11	9	30	30	20	60	23	0	1	3	14	6	24
1	2	1	2	2	0	11	9	65	45	25	52	8	0	0	1	10	10	21
0	0	3	0	1	0	17	3	40	40	30	37	11	0	0	1	9	5	15
5	0	1	0	2	0	18	2	50	40	10	35	20	0	0	0	11	3	14
33	17	26	16	11	3	168	71	47	52	26	44							
4	0	14	0	0	0	19	1	20	70	30	22	0						
6	1	2	0	0	0	17	3	25	60	40	10	0						
5	3	0	0	0	0	15	5	30	25	10	37	0						
3	1	1	0	0	0	17	3	65	65	30	30	0						
8	2	1	1	0	0	16	4	55	85	25	37	0						
1	0	3	0	2	0	19	1	30	60	35	17	0	0	0	0	4	3	7
2	1	6	1	2	0	16	4	65	55	35	32	0	0	0	2	8	3	13
4	2	3	1	4	1	14	6	40	70	35	35	0	0	2	1	7	4	14
0	0	3	1	6	0	16	4	60	55	30	42	21	0	0	2	11	4	17
33	10	33	4	14	1	149	31	43	61	30	29							

1 1 1 1 1 1½ 1½ 2 2 2 2 2 2 2 1½ 1½ 1½ 1½ 3

ABSTRACT of Medical Examinations of 34 *villages,*

Villages.	Children of all Classes.		Adults.					
			Brahmins, Fukeers, &c.		*Hindoo cultivators.*		*Mussulman cultivators.*	
	N	E	N	E	N	E	N	E
Gungoh, ...	14	6	1	0	6	0	3	1
Beera Kheree, ...	16	4	2	1	12	1	1	0
Umbehta, ...	14	6	1	0	4	0	2	0
Kheree, ...	15	5	2	0	0	0	3	0
Sidhowli, ...	17	3	0	0	17	1	0	0
Pilkhuni, ...	16	3	1	0	8	1	0	0
Jajwa, ...	11	9	3	0	5	0	3	0
Jugehta, ...	13	7	1	1	5	0	0	0
Chitowra, ...	20	0	0	0	2	0	8	0
Tajpoor, ...	20	0	7	0	5	0	3	0
Khatowli, ...	16	4	1	0	5	0	0	0
Muhmoodpoor Lahora, ..	18	2	0	0	9	0	2	0
Sutheree, ...	17	3	4	0	4	0	1	0
Sulawah, ...	19	1	2	0	8	0	1	0
Jowalagurh, ...	19	1	2	0	5	0	0	0
Sirdhana, ...	36	4	5	0	6	0	0	0
Nanoon, ...	19	1	0	0	0	0	14	1
Bhalsowna, ...	16	4	4	0	10	0	0	0
Doongur, ...	20	0	3	0	9	0	0	0
Bhola, ...	19	1	6	0	1	0	1	0
Peeplee Adureespoor, ...	19	1	5	1	8	0	3	0
Meerut Cantonment, ...	77	3	1	0	2	0	3	0
Bhoorbural, ...	18	2	6	0	8	0	0	0
Begumabad, ...	19	1	3	2	2	0	1	1
Seekree, ...	18	2	3	0	16	0	0	0
Dohaee, ...	20	0	4	0	8	0	0	0
Kurkurree, ...	20	0	3	0	14	0	0	0
Bagouth, ...	18	2	1	0	17	0	0	0
Bhyrapoor, ...	19	1	7	0	12	0	0	0
Powyss, ...	15	5	4	0	15	0	0	0
Sunowli, ...	19	1	0	0	16	1	0	0
Sherpoor, ...	17	3	0	0	13	0	1	0
Solana, ...	14	6	4	0	12	0	0	0
Mokundpoor, ...	15	5	1	0	13	0	2	0
	663	96	87	5	277	4	52	3

&c., practising Well Irrigation in the Northern Dooab.

Adults.																				
Bunnias.		*Artisans, &c.*		*Menials, &c.*		*Totals.*		*Per centage of adults having suffered from fever in*			*Per centage of enlarged spleens.*	*Depth of water from the surface of ground.*	*Detail of sizes of enlarged spleens.*							
N	E	N	E	N	E	N	E	1844	1845	1846		Feet.	VL	L	M	O	S	Total.		
1	0	4	0	4	0	19	1	70	55	40	17	16	0	0	0	2	5	7		
0	0	3	0	0	0	18	2	55	55	40	15	20	0	0	0	1	5	6		
7	0	4	0	2	0	20	0	60	35	10	15	11	0	0	0	4	2	6		
5	1	5	1	3	0	18	2	25	45	55	17	15	0	0	0	5	2	7		
0	0	2	0	0	0	19	1	25	15	5	10	14	0	0	0	1	3	4		
0	0	1	0	0	0	10	1	36	45	36	13	12	0	0	0	2	2	4		
5	1	3	0	0	0	19	1	65	7[illegible]	35	25	14	0	0	0	3	7	10		
4	0	5	0	4	0	19	1	20	30	15	20	11	0	0	0	5	3	8		
2	0	7	0	1	0	20	0	30	40	10	0	30	0	0	0	0	0	0		
0	0	1	0	4	0	20	0	30	10	0	0	19	0	0	0	0	0	0		
10	0	3	0	1	0	20	0	60	15	10	10	20	0	0	0	1	3	4		
5	0	1	0	3	0	20	0	35	25	30	5	20	0	0	0	0	2	2		
3	0	7	0	1	0	20	0	55	15	20	7	22	0	0	0	0	3	3		
4	0	4	1	0	0	19	1	20	25	5	5	20	0	0	0	1	1	2		
4	0	8	0	1	0	20	0	40	50	30	2	25	0	0	0	0	1	1		
13	0	12	0	4	0	40	0	32	35	17	5	20	0	0	0	2	2	4		
3	0	0	0	1	1	18	2	35	35	35	7	17	0	0	0	2	1	3		
0	0	3	0	3	0	20	0	35	30	5	10	24	0	0	0	0	4	4		
0	0	4	0	3	0	20	0	25	20	20	0	35	0	0	0	0	0	0		
1	0	5	0	4	0	20	0	20	25	10	2	22	0	0	0	1	0	1		
3	0	1	0	2	0	19	1	25	5	10	5	25	0	0	1	1	0	2		
0	0	30	0	11	0	80	0	29	29	16	2	12	0	0	0	2	1	3		
33	0	1	0	2	1	17	3	35	25	30	12	19	0	0	0	2	3	5		
0	2	5	0	2	0	17	3	35	30	25	10	27	0	0	0	0	4	4		
4	0	0	0	1	0	20	0	0	0	0	5	29	0	0	1	0	1	2		
0	0	1	0	3	0	20	0	35	40	20	0	32	0	0	0	0	0	0		
4	0	0	0	2	0	20	0	30	30	10	0	35	0	0	0	0	0	0		
1	0	0	0	2	0	20	0	20	20	20	5	36	0	0	0	0	2	2		
0	0	0	0	2	0	20	0	20	20	20	5	36	0	0	0	0	2	2		
0	0	0	0	1	0	20	0	35	10	25	2	38	0	0	0	0	1	1		
0	0	0	0	1	0	20	0	20	10	10	12	44	0	0	0	3	2	5		
0	0	1	0	2	0	19	1	35	15	10	5	35	0	0	0	0	2	2		
1	0	0	0	5	0	20	0	55	30	10	7	38	0	0	0	1	2	3		
0	0	0	0	3	1	19	1	45	50	10	17	36	0	0	0	1	6	7		
1	1	1	0	1	0	19	1	45	50	30	15	33	0	0	0	3	3	6		
114	5	122	2	77	3	729	22	37	31	20	8	24								

ABSTRACT of Medical Examinations of 20 unirrigated villages of which 5 are

Situation.	Villages.	Children of all Classes.		Adults.							
				Brahmins, Fukeers, &c.		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunnias.*	
		N	E	N	E	N	E	N	E	N	E
Ganges Khadir, ...	Kunkhul, ...	14	6	8	1	1	1	0	0	4	0
	Jowalapoor, ..	19	1	6	1	0	0	0	0	3	0
	Buhadurabad, ..	17	3	1	0	3	2	2	0	4	1
	Santul Shah, ..	11	9	4	1	4	5	0	0	0	0
	Budheree, ...	17	3	5	0	0	0	8	2	1	0
		78	22	24	3	8	8	10	2	12	1
Bangur or high land of the Dooab, ..	Punniala, ...	15	5	4	0	8	1	1	0	1	0
	Roorkhi, ...	17	3	3	0	3	0	5	0	1	0
	Munglour, ...	30	0	4	0	2	0	8	1	5	0
	Hurriabas, ...	18	2	0	0	15	0	0	0	0	0
	Liburheree,.. ..	20	0	5	0	8	0	0	0	1	0
	Muhmoodpoor, ..	19	1	7	0	11	0	0	0	0	0
	Poor, ...	19	1	2	0	1	0	8	0	0	0
	Togulpoor, ...	19	1	1	0	3	0	0	0	5	0
	Khai Khera, ..	20	0	3	0	11	1	0	0	1	0
	Nirgajni, ...	20	0	1	0	16	0	0	0	0	0
	Belra, ...	20	0	2	0	4	0	0	0	8	0
	Bhopa, ...	20	0	5	0	6	0	0	0	1	0
	Yusufpoor, ...	20	0	2	0	10	0	2	0	1	0
	Jaolee, ...	20	0	3	0	1	0	10	0	1	1
	Kowal, ...	19	1	2	0	0	0	4	0	5	1
		296	14	44	0	99	2	38	1	30	2

in the N. W. Khadir of the Ganges, and 15 *are situated on the high land of the Dooab.*

Adults.																			
Artisans, &c.		Menials, &c.		Totals.		Per centage of adults having suffered from fever in			Per centage of enlarged spleens.	Depth of water from the surface of ground.	Detail of sizes of enlarged spleens.								
N	E	N	E	N	E	1844	1845	1846		Feet.	VL	L	M	O	S	Total.			
4	0	0	1	17	3	30	35	30	22	18	0	0	1	4	4	9			
8	0	2	0	19	1	35	30	30	5	56	0	0	0	0	2	2			
2	0	4	1	16	4	25	40	35	17	34	0	0	1	2	4	7			
1	3	1	1	10	10	60	60	20	47	9	1	0	3	9	6	19			
2	0	2	0	18	2	55	45	25	12	9	0	0	0	4	1	5			
17	3	9	3	80	20	41	42	28	21	25									
3	0	2	0	19	1	60	60	20	15	18	0	0	0	3	1	4			
3	0	5	0	20	0	25	45	25	7	28	0	0	0	3	0	3			
6	0	4	0	29	1	32	37	22	2	45	0	0	0	0	1	1			
3	0	2	0	20	0	35	5	10	5	15	0	0	0	0	2	2			
4	0	2	0	20	0	35	20	5	0	49	0	0	0	0	0	0			
0	0	2	0	20	0	5	30	5	2	58	0	0	0	1	0	1			
7	0	2	0	20	0	35	25	15	2	0	0	0	0	1	0	1			
9	0	2	0	20	0	45	50	25	2	62	0	0	0	0	1	1			
1	0	2	1	18	2	30	35	10	5	62	0	0	1	0	1	2			
1	0	2	0	20	0	25	20	5	0	73	0	0	0	0	0	0			
5	0	1	0	20	0	55	35	15	0	58	0	0	0	0	0	0			
5	0	3	0	20	0	30	15	0	0	54	0	0	0	0	0	0			
2	0	3	0	20	0	15	30	5	0	52	0	0	0	0	0	0			
2	0	2	0	19	1	20	30	20	2	40	0	0	0	0	1	0			
5	0	3	0	19	1	30	10	10	5	29	0	0	0	1	1	2			
56	0	37	1	304	6	32	30	13	3	46									

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L P. 40 (43)

ABSTRACT of Medical Examinations of 19 *Irrigating villages situated within*

Villages.	Children of all Classes.		Adults.											
			Brahmins, Fukeers, &c.		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunnias.*		*Artisans, &c.*		*Menials, &c. &c.*	
	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Selimpoor, ...	5	15	1	2	11	6	0	0	0	0	0	0	0	0
Behtuh, ...	9	11	2	1	4	1	7	1	0	1	2	1	0	0
Sukulpoor, ...	17	3	0	0	18	1	0	0	0	0	1	0	0	0
Surrowli, ...	18	2	3	0	15	1	0	0	0	0	0	1	0	0
Duggurpoor, ...	15	5	1	1	11	0	0	0	3	0	2	0	2	0
Binnapoor, ...	20	0	0	0	11	1	1	0	0	0	4	0	3	0
Rutowl, ...	15	5	0	0	0	0	15	1	0	0	1	0	1	2
Moobarikpoor, ...	16	4	5	2	10	1	0	0	0	0	0	0	2	0
Muhrumpoor, ...	18	2	1	0	16	1	0	0	0	0	0	0	2	0
Deola, ...	13	7	2	0	4	2	5	1	2	1	1	0	2	0
Busode, ...	14	6	0	0	0	0	15	2	0	0	1	0	2	0
Nugla, ...	15	5	3	1	8	1	0	0	0	0	2	3	1	1
Ulawalpoor, ...	11	9	1	0	7	5	0	0	1	2	2	0	1	1
Barote, ...	11	9	1	1	6	2	0	0	3	0	2	1	3	1
Romalla, ...	12	8	2	3	7	2	0	1	0	0	1	0	3	1
Kukripoor, ...	12	8	1	0	12	2	0	1	0	0	1	1	1	1
Nalla, ...	10	10	4	0	11	0	0	0	1	0	2	0	1	1
Kandla, ...	13	7	1	0	8	2	4	1	2	0	1	0	1	0
Khundraoli, ...	13	7	0	1	14	2	0	0	0	0	0	1	2	0
. . . . .	257	123	28	12	173	30	47	8	12	4	23	8	27	8

half a mile of the Suharunpore or Eastern Jumna Canal, in the Southern Division.

Totals.		Adults.			Per centage of adults having suffered from fever in	Per centage of enlarged spleens.	Depth of water from the surface of ground.	Detail of sizes of enlarged spleens.					Annual average amount of canal irrigation.			Average annual amount of irrigated rice.
													Tor.	Daul.	Total.	
N	E	1844	1845	1846			Feet.	VL	L	M	O	S	Total.	Beegas.	Beegas.	Beegas.	Beegas.
12	8	50	50	45	57	7	0	2	1	12	8	23	47	0	47	10
15	5	40	30	30	40	19	0	0	2	10	4	16	365	19	384	26
19	1	50	35	15	10	32	0	0	0	3	1	4	216	37	253	0
18	2	50	45	25	10	24	0	0	1	0	3	4	217	284	501	4
19	1	45	40	10	15	30	0	0	1	2	3	6	342	88	430	16
19	1	65	40	5	2	32	0	0	0	0	1	1	12	25	37	0
17	3	0	0	0	20	33	0	0	0	6	2	8	633	338	971	22
17	3	40	40	0	17	33	0	0	0	4	3	7	63	504	567	23
19	1	40	60	10	7	37	0	0	0	2	1	3	103	155	258	18
16	4	70	60	20	27	24	0	0	1	5	5	11	673	844	1516	41
18	2	65	50	25	20	24	0	0	0	4	4	8	209	622	831	22
14	6	60	50	10	27	21	0	1	0	4	6	11	59	131	190	21
12	8	25	30	5	42	18	0	0	4	7	6	17	757	6	763	76
15	5	65	55	20	35	26	0	1	3	8	2	14	970	819	1789	155
13	7	50	40	25	37	21	0	0	2	5	8	15	2366	50	2416	320
15	5	45	15	5	32	27	0	0	0	5	8	13	1491	6	1497	209
19	1	45	15	10	27	21	0	0	3	5	3	11	1062	489	1551	182
17	3	30	20	15	25	23	0	0	0	4	6	10	2314	1591	3905	268
16	4	35	40	25	27	14	0	0	1	3	7	11	1898	18	2015	107
310	70	48	40	17	25	24										

ABSTRACT of Medical Examinations of 12 *Irrigating villages more than half*

Villages.	Children of all Classes.		Adults.											
			Brahmins, Fakeers, &c., &c.		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunnias.*		*Artisans, &c.*		*Menials, &c., &c.*	
	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Gunowli, ...	20	0	0	0	18	1	0	0	0	0	0	0	1	0
Meethlee, ...	18	2	2	0	14	1	0	0	1	0	0	0	2	0
Jounmana, ...	11	9	4	0	12	2	0	0	0	0	0	0	0	2
Dukana, ...	10	10	2	1	8	1	0	0	2	0	3	0	2	1
Loharra, ...	12	8	2	0	11	0	0	0	1	0	4	0	2	0
Bazeedpoor, ...	15	5	1	0	9	0	0	0	0	0	5	0	5	0
Bujwarra, ...	17	3	4	0	8	1	0	0	2	0	2	0	1	2
Fazilpoor, ...	12	8	2	0	12	1	0	0	0	0	3	0	2	0
Kumalla, ...	18	2	3	0	12	1	0	0	1	0	0	0	3	0
Rammuggur, ...	16	4	7	1	4	0	0	0	0	0	6	0	2	0
Tetrouda, ...	15	5	0	0	12	3	0	0	1	0	0	0	3	1
Soontee, ...	10	10	3	0	6	2	0	1	0	0	5	1	2	0
	174	66	30	2	126	13	0	1	8	0	28	1	25	6

a mile distant from the Suharunpoor or Eastern Jumna Canal, in the S. Division.

Totals.		Adults.			Per centage of adults having suffered from fever in	Per centage of enlarged spleens.	Depth of water from the surface of ground.	Detail of sizes of enlarged spleens.						Annual average amount of canal irrigation.			Average annual amount of irrigated rice.
														Tor.	Daul.	Total.	
N	E	1844	1845	1846			Feet.	VL	L	M	O	S	Total.	Beegas.	Beegas.	Beegas.	Beegas.
19	1	60	15	10	2		27	0	0	0	1	0	1	278	27	305	0
19	1	50	40	15	7		32	0	0	0	3	0	3	172	253	425	33
16	4	30	15	15	32		29	0	0	1	8	4	13	89	202	291	4
17	3	50	50	30	32		30	0	0	1	10	2	13	136	228	364	29
20	0	30	30	5	20		35	0	0	0	5	3	8	224	26	250	19
20	0	25	15	0	12		36	0	0	0	3	2	5	25	55	80	0
17	3	45	30	10	15		43	0	0	0	2	4	6	179	281	460	15
19	1	70	20	5	22		36	0	0	1	5	3	9	339	122	460	41
19	1	30	25	25	7		43	0	0	0	1	2	3	199	0	199	12
19	1	60	25	20	12		34	0	0	0	2	3	5	64	0	64	4
16	4	50	60	15	22		33	0	0	0	4	5	9	924	12	936	56
16	4	60	30	20	35		28	0	0	0	3	11	14	518	3	521	82
217	23	47	30	14	18		34										

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ABSTRACT of Medical Examinations of 18 *villages, Irrigating from the are within half a mile of the Canal,*

Situation.	Villages.	Children of all Classes.		Adults.													
				Brahmins, Fukeers, &c.		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunnias.*		*Artisans, &c.*		*Menials, &c.*		*Totals.*	
		N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E
Within half a mile of Canal.	Bhynswal, ..	4	16	1	2	7	4	0	0	1	2	1	0	2	0	12	8
	Khyle, ..	2	18	2	0	3	7	0	0	1	0	0	2	4	1	10	10
	Kheree Gudhai,	3	17	1	0	8	3	0	0	1	1	1	3	1	1	12	8
	Manukpoor, ..	6	14	2	3	7	0	1	0	0	0	1	4	2	0	13	7
	Berkheree, ..	6	14	1	0	1	0	0	0	0	1	1	0	8	8	11	9
	Poojna, ..	6	14	2	0	5	4	0	0	1	1	3	1	3	0	14	6
	Munowra, ..	5	15	1	0	10	3	0	0	0	0	2	0	3	1	16	4
	Abba, ..	6	14	1	1	0	0	6	4	0	4	1	1	1	1	9	11
	Anutmhow, ..	1	19	0	0	7	7	0	0	1	0	2	1	2	0	12	8
		39	141	11	6	48	28	7	4	5	9	12	12	26	12	109	71
District more than ½ a mile from Canal.	Mundait, ..	2	18	1	0	7	7	0	0	0	0	0	0	4	1	12	8
	Mulhendee, ..	8	12	2	0	11	2	0	0	1	0	1	1	2	0	17	3
	Papuree, .	1	19	1	0	0	0	9	7	0	0	1	0	1	1	12	8
	Teetroon, ..	8	12	2	0	7	1	1	0	2	2	3	0	0	2	15	5
	Teekrowl, ..	4	16	2	0	10	2	0	0	1	1	1	1	2	0	16	4
	Hingowli, ..	5	15	2	1	5	3	0	0	0	2	1	1	4	1	12	8
	Dhakaday, ..	8	12	1	1	9	2	2	0	0	0	1	0	4	0	17	3
	Sejour, .	3	17	0	0	2	1	10	0	0	0	2	1	2	2	16	4
	Kunjowlee, ..	15	5	0	1	0	0	11	2	0	0	1	0	5	0	17	3
		54	126	11	3	51	18	33	9	4	5	11	4	24	7	134	46

Suharunpore or Eastern Jumna Canal, in the centre Division, of which 9 villages and 9 villages are at a greater distance.

Per centage of adults having suffered from fever in			*Per centage of enlarged spleens.*	*Depth of water below the surface of ground.*	*Detail of sizes of enlarged spleens.*					*Annual average amount of canal irrigation.*			*Annual average amount of irrigated rice.*
										Tor.	Daul.	Total.	
1844	1845	1846		Feet.	VL	L	M	O	S	Totals.	Beegas.	Beegas.	Beegas.	Beegas.
40	35	30	60	7	0	0	2	12	10	24	2108	289	2397	542
60	45	40	70	6	0	2	4	18	4	28	779	58	836	249
85	65	15	62	3	0	0	2	15	8	25	485	3	488	143
75	65	35	52	8	0	0	1	12	8	21	371	87	458	130
50	65	40	57	8	0	1	5	7	10	23	230	65	294	143
50	45	15	50	9	0	0	2	8	10	20	242	57	299	74
70	50	30	47	9	0	0	0	9	10	19	370	23	393	104
50	40	5	62	11	0	2	5	10	8	25	455	32	487	159
90	80	65	68	7	0	0	5	14	8	27	491	116	607	208
63	54	31	59	8										
35	35	25	65	20	0	0	6	16	4	26	503	145	648	121
50	40	25	37	14	0	1	3	5	6	15	38	17	55	0
55	65	35	67	11	0	0	5	12	10	27	592	20	613	252
75	45	25	42	16	0	0	3	4	10	17	600	13	613	45
85	60	30	50	11	0	1	3	8	8	20	1530	80	1610	523
60	55	35	57	17	0	0	1	10	12	23	329	55	384	0
55	55	20	37	18	0	0	0	5	10	15	117	0	117	78
50	65	50	52	11	0	0	1	11	9	21	496	143	639	201
70	60	35	20	12	0	0	0	3	5	8	160	108	268	78
60	53	33	47	14										

ABSTRACT of Medical Examinations of 15 villages, &c., under various circum-

Circumstances.	Villages.	Children of all Classes.		Adults.											
				Brahmins, Fukeers, &c.		*Hindoo cultivators.*		*Mussulman cultivators.*		*Bunnias.*		*Artisans, &c., &c.,*	
		N	E	N	E	N	E	N	E	N	E	N	E
Irrigating within half a mile of Canal.	Reeree, ..	7	13	3	0	8	3	0	0	1	0	3	0
	Rutnakhera, ..	13	7	0	1	5	2	0	0	0	0	7	1
	Manickmhow, ..	12	8	4	0	5	1	0	0	1	0	3	2
	Rundole, ..	17	3	1	0	4	1	0	0	2	0	8	1
	Kulsea, ...	19	1	3	0	8	0	0	0	3	0	0	0
	Raipoor, ..	19	1	5	0	4	0	2	0	1	0	5	0
		87	33	16	1	34	7	2	0	8	0	26	4
Irrigating distant more than half a mile from Canal.	Nowabas, ..	11	9	0	0	13	1	0	0	1	1	2	0
	Hurpal, ..	12	8	0	0	0	0	5	1	5	1	6	0
	Suhujwa, ..	17	3	4	0	10	0	0	0	1	0	0	0
	Beetia, ..	15	5	2	1	7	2	0	0	0	1	4	0
	Suharunpore, ..	31	29	4	1	7	6	5	2	8	1	13	4
	Behut, ..	18	2	0	0	2	1	7	0	4	1	3	0
		104	56	10	2	39	10	17	3	19	5	28	4
Unirrigated near head of Canal.	Nyashuhur, ..	19	1	1	0	6	0	1	0	0	0	8	0
	Tanda, ..	20	0	0	0	6	0	0	0	0	0	3	0
	Fyzabad, ..	15	5	2	0	6	0	0	0	2	0	3	1
		54	6	3	0	18	0	1	0	2	0	14	1

stances in the Northern Division of the Suharunpore or Eastern Jumna Canal.

Menials, &c, &c.		Adults.																		
Totals.				Per centage of adults having suffered from fever in			Per centage of enlarged spleens.	Depth of water from surface of ground.	Detail of sizes of enlarged spleens.							Annual average amnt. of canal irrigation.			Average annual amount of Irrigated Rice.
																Tor.	Daul.	Total.	
N	E	N	E	1844	1845	1846		Feet.	VL	L	M	O	S	Total.		Beegas.	Beegas.	Beegas.	Beegas.
2	0	17	3	55	65	25	40	3	0	0	1	6	9	16		436	72	508	56
3	1	15	5	40	55	25	30	9	0	0	0	5	7	12		82	10	92	15
3	1	16	4	25	35	5	30	12	0	0	0	6	6	12		403	123	526	148
3	0	18	2	10	50	55	12	7	0	0	1	2	2	5		643	86	729	413
5	1	19	1	10	15	10	5	8	0	0	0	1	1	2		0	0	0	0
3	0	20	0	20	15	45	2	0	0	0	0	1	0	1		52	3	55	0
19	3	105	15	27	39	27	20	8	0	0									
2	0	18	2	55	40	40	27	9	0	0	0	3	8	11		272	180	452	117
2	0	18	2	40	70	30	25	16	0	0	1	4	5	10		41	18	59	6
4	1	19	1	10	25	10	10	11	0	0	0	0	4	4		99	183	282	14
3	0	16	4	60	60	20	22	18	0	0	0	3	6	9		3	0	3	0
7	2	44	16	33	45	40	38	8	0	3	5	20	17	45		0	0	0	0
2	0	18	2	25	40	40	10	18	0	0	0	1	3	4		41	4	45	0
20	3	133	27	37	47	30	22	13	0	0	0								
4	0	20	0	25	30	10	2	0	0	0	0	0	1	1		0	0	0	0
11	0	20	0	35	40	30	0	0	0	0	0	0	0	0		0	0	0	0
6	0	19	1	45	60	40	15	0	0	0	0	3	3	6		0	0	0	0
21	0	59	1	35	43	27	6												

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48 — *Summary or General Abstract*

Irrigated from the *Western Jumna Canals.*	Delhi Branch,	....	....	....
	Rohtuk Branch,	....	....	....
	Bootana Branch,	....	....	....
	Hansi Branch,	....	....	....
Irrigated from the *Eastern Jumna Canals.*	Northern Division,	....	....	....
	Centre Division,	....	....	....
	Southern Division,	....	....	....
Irrigated from *wells* in the high land of the Dooab,		....	....	....
Unrrigated.	Sikh States,	....	....	....
	Delhi Territory,	....	....	....
	Northern Doab,	....	....	....
	Naturally malarious localities,		....	....

5

of Medical Examinations.

	Per centage of enlarged spleens.	Per centage of adults having suffered from fever in			Average depth of water from surface of ground
	Adults and Children of all Classes.	1844	1845	1846	Feet.
Within half a mile of the Canal, ..	58	51	45	41	11
Distant more than half a mile, ..	49	51	49	40	18
Within half a mile of the Canal, ..	44	47	38	27	28
Distant more than half a mile, ..	29	34	34	27	48
Distant more than half a mile, ..	16	41	36	22	102
Within half a mile of the Canal, ..	39	50	41	22	92
Distant more than half a mile, ..	18	40	31	16	118
Within half a mile of the Canal, ..	20	27	39	27	8
Distant more than half a mile, ..	22	37	47	30	13
Within half a mile of the Canal, ..	59	63	54	31	8
Distant more than half a mile, ..	47	60	53	33	14
Within half a mile of the Canal, ..	25	48	40	17	24
Distant more than half a mile, ..	18	47	30	14	34
.. ..	8	37	31	20	24
Connected with the Canal, ..	44	47	52	26	0
Unconnected with the Canal, ..	29	43	61	30	0
Unconnected with the Canal, ..	11	32	28	11	88
High or Bangor land, ...	3	32	30	13	46
Ganges Khadir, ...	21	41	42	28	25
Near head of Eastern Jumna Canal,	6	35	43	27	0
Nujufgurh Jheels, ...	44	42	59	57	15
Valleys of Jumna and Hindun, ...	34	46	42	31	14

APPENDIX E.

Abstract of the Medical Examinations, affording the principle data for the fore-going Report.

The recorded numbers of natural and enlarged spleens may be received as representing authentic facts.

The per centage of sufferers from fever in the several years is deduced from the records of oral testimony collected by the Committee, and may possibly in many instances be not strictly correct. It is hoped however, that in the general averages will be found an approximation to the truth, and the means of comparing with tolerable certainty the salubrity of different years.

The depths of water from the surface of ground were ascertained bv actual measurement and the information regarding the extent and nature of Canal irrigation was furnished by the Superintendents of the respective Canals.

Explanation of the headings, used in the subjoined Abstracts.

N. Natural or healthy spleens.

E. Enlarged spleens.

VL. L. &c. Sizes of spleens as in Appendix C.

Tor irrigation is where the water flows naturally over the soil as distinguished from

Daul irrigation, where the water is artificially raised to the level of the ground.

The areas of irrigated land are stated in beegas of 3,025 square yards, 640 beegas being equal to 1 square mile.

APPENDIX F.

Measures connected with the execution and management of the proposed Ganges Canal, alluded to in paragraph 15 of the Report, as deserving the attention of Government.

The Committee would recommend as follows:—

1st That the Ganges Canal be kept as much as possible within soil, i. e. that its ordinary surface level should be below that of the country.

2nd. That earth wanted to complete embankments, be never obtained from excavations made outside of the canal, except in such localities as will readily admit of drainage.

3rd. That the canal and its branches be taken as much as possible along the water-shed line of the country, so as not to interfere with drainage, and in all cases where such interference may be unavoidable, that the executive office be instructed to provide otherwise for the drainage.

4th. That masonry drains be constructed under Rajbuhas or Bridge Ramps, whenever these cross the drainage of the country.

5th. That no private water-courses be allowed, but that irrigation be practised exclusively from Rajbuhas or main water-courses.

6th. That irrigation be prohibited within five miles of a military station and within one or two miles of large native towns.

7th. That in clearing embankments, the grass, weeds, &c., be not suffered to rot on the ground, but that they be burned as soon as possible after they are cut.

8th That irrigation be altogether prohibited in localities which appear naturally to possess a malarious character.

The Committee are aware that the adoption of the measures above recommended would involve an expense not contemplated in the original estimates for the Ganges Canal.

(Signed) W. E. BAKER, Major, *Engineers and President.*

(Signed) T. E. DEMPSTER, Surgeon, *Member.*

APPENDIX G.

Comparative Abstract shewing the Ratio of Population to area in certain irrigated and unirrigated districts of the North Western Provinces.

Detail of Irrigation, &c.	Name of Collectorate.	Number of Villages.	Aggregate area in Beegas of 3025 square yards.	Aggregate Population.	Population per square mile.	Average Population per square mile.
Irrigated from Canals.	Paniput, ..	96	329,947	74,360	231	
	Delhie, ..	49	101,472	33,754	341	
	Rohtuk, ..	52	221,262	60,007	278	317
	Hissar, ..	35	224,563	11,485	54	
	Mozuffernuggur, ..	15	23,195	15,406	680	
Irrigated from Wells.	Mozuffernuggur, ..	100	118,856	57,665	497	0
Unirrigated.	Paniput, ..	29	61,194	12,320	206	
	Rohtuk, ..	61	373,531	59,895	164	
	Hissar, ..	40	323,207	16,014	51	165
	Mozuffernuggur, ..	73	95,416	22,189	238	

This Abstract is referred to in paragraph 19 of the Report.

(Signed) W. E. BAKER, MAJOR,
President.

(Signed) T. E. DEMPSTER, SURGEON,
Member.

APPENDIX H.

Abstract of some of the principle facts recorded in the report of a Medical Committee appointed in the Government of Madras to investigate the causes of an epidemic fever which prevailed in the Provinces of Coimbatore, Dindigul, Madura and Tinnevelly, during the years 1809, 1810 *and* 1811.

Tne soil of Coimbatore is in general dry, but there is no want of extensive tanks. In the vicinity of the Hills is much low marshy ground, and many villages in such situations are proverbially unhealthy. On the whole the Coimbatore country may be called healthy in common years.

Dindigul is a mountainous and woody country, encompassed by high lands, and more or less covered by Jungle of prodigious height. Climate stated to be proverbially healthy in common years.

Madura is a more open and less mountainous country than Dindigul; it is hotter in the hot season and not quite so cold in the months of December and January. The climate of this district, in common seasons, cannot by any means be considered unhealthy, although the fort has been so for several years, and before the epidemic prevailed. Like most mountainous countries in the torrid zone, Madura has situations where fever never fails, at certain seasons, to be endemic; but the disease does not generally spread beyond these localities. There are some villages close to, and amongst the Hills, lying in the most western parts of the province, in which, in the months of March and April, no man can pass a single night without suffering an attack of fever soon after. Both the houses and clothing of the inhabitants are of a very inferior description.

Tinnevelly is considerably lower than any of the other provinces in which the epidemic prevailed; it may, in the strictest sense, be called an open country; as few Hills are to be found in it, and those are isolated or detached. It contains several waste and jungly tracts, especially towards the east. There are also, here and there, extensive low and marshy lands in the vicinity of the mountains, &c. Situations at a certain distance from the Hills, are higher and drier than those which are nearer to them. Culpettie, standing in a fine elavated country, was comparatively comfortable and healthy, whilst Tewancootshie, due west from the former and close to high land, was found nearly surrounded with wet ground, damp, ruinous and almost depopulated. Towards the southern and eastern extremity of the peninsula, there are many salt marshes, formerly distinct from each other, but four of them now (date of report) joined together, owing to recent inundations. They are separated from the sea by high sand hills, and have no natural communication with it. In common years there is not much water collected

in them, but since the heavy monsoon of 1810, and especially since the rains which fell in February and March, out of all season, they have been filled to a depth of 5, 7 or 10 feet, and the water by remaining long in a state of stagnation has been productive of infinite mischief. In December 1810, the inhabitants of villages near these salt swamps (10 or 12 in number), complained that their houses were rendered uninhabitable, their lands flooded, and that water had risen so high on their Palmyra trees that they were unable to draw the "Toddy." The valley of Courtallum however delightful its climate in June, July, August and September, is far otherwise in February, March, April and May; it partakes of both monsoons, and from its singular topographical position is, in a great measure, deprived of the salutary influence of the southerly winds. At the last mentioned period, it is close, hot and sultry in the greatest degree, and never fails to be most unhealthy. Endemic fever, at such times, is as certainly met with here, as at Gambia or Senegal. On the whole the epidemic fever has raged with the greatest violence in Tinnevelly.

General causes—Believed to be unusual and irregular seasons. Several remarkably dry seasons (themselves healthy), followed by seasons in which an unusual quantity of rain fell, prevailing winds blew with less regularity. Many cattle died, as much from an unnatural state of the atmosphere, as from a want of hands to feed and take care of them.

Progress.—The epidemic was first noticed in certain places close to the Hills, marshy and proverbially unhealthy; and afterwards spread over tracts naturally drier and more healthy. Certain parts of the Madura Collectorate near the sea, or rather further removed from the range of mountains, escaped the disease altogether; with the exception of the inhabitants in the vicinity of a salt marsh. Tinnevelly appears to have been last in suffering from the epidemic. The fever invariably proved most destructive in those villages nearest the Hills, in villages standing low or in the vicinity of marshy lands, and among the poor ill fed and badly lodged population.

The disease which proved so fatal in the southern provinces, does not differ from the common endemic of the country, which, at certain seasons, and in particular situations, may be every year met with. Its having been rendered epidemic on the present occasion, is altogether to be ascribed to the causes already mentioned.

(Signed) W. E. BAKER, MAJOR,
President.

(Signed) T. E. DEMPSTER, SURGEON,
Member.

APPENDIX I.

COPY.

To Major W. E. BAKER,
President Canal Committee.

From A KEIR, *Civil Surgeon,*
Ajmeer.

Ajmeer, 18th January, 1847.

Sir,

I have the honor, in reply to your letter No. 886 of 1846-47, under date the 11th December last, to submit the following observations, as the result of the enquiries I have made regarding the effect of irrigation practised in this district upon the health of the cultivators.

A.

In the first place, relative to the expression made use of in your communication, "extensive irrigation," I would beg to remark, that it seems applicable rather to denote the condition of the district *as it now is*, with reference to its former unimproved state before coming under Major Dixon's management, than the actual amount of *irrigated* as compared with *unirrigated* land to be found within its limits.

External feature of the country.

Characteristic of this part of the country generally, and of the Ajmeer district in particular, are the numerous ranges of rocky hill which give a bold and rugged aspect to the scenery, but which tend in no less degree to modify the soil and its productions. From these hills come down numerous small streams, the channels of which remain dry during a great part of the year, but speedily fill after a heavy fall of rain. It is by taking advantage of the water thus poured upon the ground, by making embankments, and so laying it under contribution, that some degree of fertility is imparted to a district otherwise of a highly unpromising and unfruitful description. Wonderful indeed and pleasing is the change which has been effected by such means. The waste has been subdued in many places, and instead of a bare, barren-looking surface, producing only a few thorny shrubs, there is now to be seen a smiling sheet of cultivation; and this extending year by year as the skill and industry of the people can be brought to bear on the work of improvement.

Geological character of the hills.

The hills of this district of country belong to the primitive formation. They consist principally of granite rock, (granite and gneiss) quartz-mica and hornblende schist; crystaline limestone is found in the vallies, but the crystals large and the stone of a coarse description. The materials composing the rocky masses are aggregated in every variety of way and proportion, and hence occurs a great diversity in the color, aspect and consistence of the different rocks.

Inclination of the strata.

The general structure of the rocks is schistose, and the strata for the most part have a very high inclination. The dip varies exceedingly. Hereabouts it seems to be more often from west to east; but in other parts the opposite direction prevails. There can be no particular rule laid down in this respect, as regards the lakes or reservoirs for irrigation. These are found on one side of the hill as well as the other, and in the vallies between different ranges. Without minute investigation, the direction of the strata may generally be judged of by the appearance of the hill, the steep abrupt face showing the broken termination of the strata; the opposite more inclined face indicating their direction upwards. In many places, the strata seem perpendicular to the surface, or very nearly so.

Soil.

The soil of the district is composed of the "debris" of these different rocks. It is in a large part silicious; but mica abounds in it and also felspar. The latter ingredient, washed down by the nullahs, exists abundantly in the beds of talaos or tanks, and there gives a clayey consistence to the soil. A "light reddish loam" may perhaps be the appellation most generally applicable to designate the character of the soil. Tried with acids it effervesces tolerably freely. A correct analysis, however, I am not prepared to offer. Calcareous earth is very abundant in some situations, particularly so along the margins of nullahs, where it exists in the form of "kunkur," mixed with other gravelly matter. The proportion of material of vegetable origin is not in general great. Hence the practice of "manuring" is one diligently followed, and the crop in general rises in proportion. Indeed, without "manuring" there is little to be got from a soil so naturally poor. An exception is to be found in this respect in the beds of "talaos," where, from the washings of the stream, there is a rich alluvial deposit, and where, in consequence, excellent crops are raised independent of manure. The ground so favorably situated, however, forms but a small space. The salts which seem most to abound in the soil are those of soda, the muriate and carbonate in particular. In some parts the effervescence on the sur-

Soil, its qualities.

face is very abundant, and this has sometimes an alkaline and sometimes a strongly saltish taste. Dr. Irvine remarks that the quantity of potash in the soil, comparatively with the quantity of decomposing felspar and mica is small.

But not only is the soil poor as respects the proportion of fertilizing ingredients, it is likewise, over a considerable part of the district, deficient as to quantity. The nearness of the rock to the surface may in general be guessed at from its coming into view every here and there. In some places there appear round or tabular masses of rock; in others sharp spinous looking ridges. These latter are generally of quartz, and indicate the direction of "dykes or veins;" the material from its hardness having withstood the action which has disintegrated and decomposed the softer rocky masses around.

Country adapted for tanks.

Happily, a country of this description is well adapted to illustrate what may be done for its improvement by artificial means. The materials are on the spot, and by means of embankment way, even the smallest stream can be made to produce its full fertilizing influence upon the soil. To discern the places where embankments may be most fittingly raised requires considerable skill. But an eye accustomed to such observations will detect the ground where the water may be most easily retained, and where the work can be most advantageously undertaken.

Embankments, their uses.

The object of the embanking process is not merely to have a body of water that may be run off for the purposes of irrigation. This, though a legitimate end in many situations, is not always attainable. A tank, although it holds water only for a certain period of the year, may still serve a useful purpose by its effects in diffusing moisture throughout the neighbouring soil, and which may thus be rendered fit for cultivation. Some of the richest looking cultivation in the district is to be seen immediately along the margins of the tanks, and, progressively, in its bed as the waters recede. Another grand object, and the primary one in many cases, in the formation of these tanks is the replenishment of the wells. Very many of the wells in this district would completely fail in bad seasons, or yield a most insufficient supply, except for the influence they derive from the neighbourhood of tanks: and here may be seen the admirable beauty and utility of such works, and the inestimable benefit they confer in a district of country where the fall of rain is frequently scanty and at all times precarious. The water, whatever the season supplies, is kept as in a stone house. It may sink

into the earth; but can be again drawn forth and poured upon the surface, which thus becomes fertilized in the time of need.

Wells.

The wells, as to quantity of water and its distance from the surface, will of course vary with the state of the tank, at least all those so situated as to be affected by tanks. After a season of plentiful rain like the past, the water in most of the wells is abundant and moderately near the surface. From 30 to 40 or 45 feet* may be about the average depth at which water is obtained, but in this there is considerable variety according to situation and other circumstances. When the rains have been scanty, the supply in the wells is also apt to be scanty, and may fail during the hot weather. With the ground so saturated as it is now there need be no apprehension on this point. Even a season of "drought" ensuing after one like the past would be but partially felt.

Water of the wells and tanks, the difference.

There is a considerable difference in the chemical proportion of the water as taken from wells or from tanks. The tank water is generally much less impregnated with salts and therefore preferable for domestic purposes and most agricultural ones; so much so is this the case that in many parts the villages may be seen to use the muddied "tank water" in preference to that from the wells. Where the soil contains a large amount of salt, the well water becomes *entirely* unfit for irrigation. This is the case in some parts of the Ramsur district, where the salt effloresces abundantly on the surface. The evil is corrected in some degree by the use of tank water, and but for this the extensive khêts to be seen in that neighbourhood could have no existence. Some crops, however, as the barley, suffer less from this saline impregnation. At the station of Nusseerabad, from the want of tank water, little or nothing can be done in the way of cultivation. Gardens there are next to useless, and the best efforts lead but to disappointment. At Ajmeer, and this neighbourhood generally, the case is different. The well water is good and answers for irrigation.

Re-agents, effects of, with the water.

Water entirely free from saline impregnation is not to be found either in the wells or the tanks. From the water of all the wells I have examined the nitrate of silver throws down a copius precipitate. The "Ana Sagur" water, which is that of the lake, gives a precipitate

* I have not noticed the depth of water in the wells. I did not observe this was required till after visiting the villages. Here is 30 feet water at depth of 30 feet, which may be near the average of permanent as distinguished from temporary wells this year.

but very much fainter. In other parts of the district, I have observed the same difference in relation to tank and well water. The oxalate of ammonia gives a distinct precipitate with the "well water" of Ajmeer but there is none with that of the lake. Solution of pure potass causes a faintish precipitate with the well, but not with the lake water. The nitrate of barytes causes a precipitate with the well, but not with the tank water.

Irrigation, its effects as to the health of cultivators.

As to the effect of the irrigation practised in this district upon the health of the cultivators, information will be best gathered by a reference to the result of my enquiries on that point contained under the head marked B. The investigation was carried on by myself on the spot, and in the manner directed. Taking the results obtained as affording a criterion by which to judge of the healthiness of the cultivators throughout this district, it certainly leads to the conclusion that irrigation, as here practised, is not in any high degree injurious. The sufferers from spleen are chiefly children. As regards European children, particularly young children, I may remark that the climate of this part of India, as far as my experience goes, is not the most favourable. To my questions on the subject of fever, I found it difficult, I may say impossible, often to obtain precise answers. Whether from wilfulness or forgetfulness, the latter I believe most generally, there seemed very often no distinct recollection on the part of individuals as to whether they had suffered from attacks of fever in previous years or not. On this subject a good many mis-statements may have been made. The probability is, that when there was an indistinct recollection as to the occurrence of fever, it could not, in such cases, have been of a serious or debilitating kind.

Cultivators their healthy looks.

To form a judgment as to the health of the inhabitants from their looks and appearance there was the best evidence every where that they were far from an unhealthy race. Indeed, in few of the villages visited could I make out any considerable amount of disease. Among the most common complaints were chronic skin diseases, rheumatism, old and indolent ulcers. A good many *prematurely* old looking persons were to be found, but there is more reason to believe this a consequence of hard work and indifferent food than any effect on their constitutions produced by the climate or soil.

Questions as to effect of irrigation.

I made enquiries on many occasions, as to whether, with the increase of irrigation, there had been observed any increased amount of sickness. The reply was uniformly in the "negative." So much more, amongst

them, does consideration attach to "plenty" than to health, that the enquiry seemed to be looked upon as a highly absurd one.

The circumstances under which the irrigation is practised and which tend to render it so little hurtful, I conceive to be chiefly the following:

General nature of the climate.

The climate is essentially a dry one, and at the same time salubrious. The villages in respect to the irrigated land are almost invariably high in point of situation. For the most part they rest on the slope of a hill, either near its base or on the steep itself; or they extend along some rocky ridge. The village of Ramsir, for instance, situated as it is with a lake on one hand (and this apt to dry up in some seasons), and a freely irrigated country on the other, might certainly, from its position, be looked upon as a very *focus* in respect to malaria, yet still, as far as enquiry enabled me to find out, no great unhealthiness appears to prevail. What, in the main, conduces to this favourable, and, so far as appearances go, unexpected state of things, is, I doubt not, the situation of the village, high and dry and upon a rocky ridge. The elevation of the ridge is inconsiderable, but still the houses built upon it may be considered well placed, and in some degree removed from the immediate influence of the soil.

The villages how situated.

Nature of crops irrigated.

The most sickly time of the year is the month of October; and during this month and early in November the days are hot and the atmosphere contains much moisture. Besides this, I believe, that the newly upturned and newly irrigated soil is the most apt to give forth noxious exhalations. The *after irrigation*, provided the fields be kept free of weeds as they are here, has little if any injurious effect. The fields regularly irrigated are those of the wheat and barley, and the work goes on with little intermission until February. Irrigation is practised for other crops, at different seasons, but to a trifling extent only.

The soil as affected by irrigation.

The circumstance chiefly operative as regards the health of the people employed in irrigation in this district, I conceive to be the "absorbent nature of the soil." The underlying rocks, too, have a highly absorbent character, and hence water poured upon the surface sinks into the earth speedily. It is owing to this property of the soil that the clothing of herbage is every where so scanty. Soon after the first early rain the grass springs up, and the dry, burnt up waste becomes overspread with *green*. When the rain has ceased, or very soon after, a change in the appearance of the scene takes place. The surface becom-

ing dry, the more delicate grasses wither, and nothing has a thriving aspect but the wild shrubs and bushes such as the "ah," the kunserah, the "kenail," &c., which delight in a barren soil. Trees, when they have once struck their roots deep into the earth, and can draw from it moisture for their own support, thrive well, but, until they have arrived at this stage of growth, require much care and tending. Hence so few are to be seen and those only in the vicinity of villages.

It is easy to understand why a soil of this kind should be less injurious under the influence of irrigation than one of a different description, where the vegetation becomes more luxuriant, and where, at certain times, it is liable to decay and decomposition. Another favourable circumstance as regards this district is the little disposition of water to stagnate. The ground being inclined more or less in all parts, water runs freely and, conducted into a tank, is in the condition least of all likely to have any prejudicial effect. It is only in the immediate vicinity of Ajmere itself (at the Daulut Baugh, and in front of the magazine), that I have observed any ground covered by water in a stagnant state, and in a state likely to give forth unwholesome exhalations. From the overflowing of the Ana Sagur lake this was partly unavoidable, during the rains at least, but the evil has been allowed to exist long after the remedy, the simple one of draining, might have been applied. That this state of things has produced the great amount of fever that has prevailed in the town the last season, I am not prepared to say: but it may have had some effect. Other apparent causes exist; and the season moreover has been generally an unhealthy one, although not so, in a great degree seemingly in the smaller villages of the district.

Inclination of the surface.

Stagnant water.

One point on which information is desired is as to the amount of ground in a state between "dryness and moisture." Of natural swamps or marshes there are none, so far as I know, in the district. A few swampy spots there may be after heavy rains, but not such as to give any cause for apprehension. The condition of the Ramsir lake I have not observed at all seasons: some portion of its bed may possibly remain in the state of a swamp during the hot weather, but how much or in what *precise* condition, I am not able to say. The only *permanently* swampy ground I have observed has been immediately in the vicinity of tanks and produced either by leakage through the bund, or by water finding its way by percolation underneath. The ground in this direction, so long as there is water in the tank, remains generally *moist*, and this term expresses its condition in most cases better than swamp.

Swamps and marshes.

The drying up of the tanks begins in the opposite direction, or towards the source of supply. When there is much clay in the ground, the surface becomes hard, and *cakes* as the water gradually recedes. When there is a due proportion of vegetable mould the soil here is of the best description and affords the richest cultivation.

Drying up of tanks.

It is when lakes are in a process of drying that they are most likely to be injurious by giving out malaria. When there is plenty of water in the Ana Sagur lake no place is more desirable as a residence than the bund; but it is not so in particular seasons when a large portion of the bed of the lake has dried up. Most of the other lakes in the Ajmere district are small in comparison, and injurious consequences from this source need not be apprehended.

(Signed) A. KIER, M. D.,
Civil Surgeon.

(True Copy.)

(Signed) W. E. BAKER, Major,
President Canal Committee.

ABSTRACT of Medical Examinations referred to in the foregoing Report.

Villages.	Children of all Classes.		Adults.														Per centage of enlarged spleens.	Depth of water below surface of ground.	Detail of sizes of enlarged spleens.						Per centage of adults having suffered from fever in		
			Brahmins, Fakeers, &c.		*Hindoo Cultivators.*		*Mussulman Cultivators.*		*Bunnias.*		*Artizans, &c., &c.*		*Menials.*		*Totals.*												
	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E	Feet.	VL	L	M	O	S	Total.	1844	1845	1846
Tabeejee, ...	17	3	4	1	5	1	0	0	5	0	1	0	2	1	17	3	15	30	0	0	0	0	6	6	5	20	30
Ramsir, ...	17	3	0	1	2	1	6	2	6	0	1	0	1	0	16	4	17½	5	0	0	0	1	6	7	0	45	35
Dubreila, ...	19	1	1	0	14	0	0	0	2	0	2	0	0	1	19	1	5	25	0	0	0	1	1	2	20	10	25
Neepoolie, ...	20	0	0	0	18	0	0	0	2	0	0	0	0	0	20	0	0	12	0	0	0	0	0	0	5	5	5
Saproonda,....	18	2	0	0	9	2	0	0	1	1	2	0	5	0	17	3	12½	25	0	0	0	1	4	5	5	5	20
Teharie, ...	14	6	2	1	6	1	0	0	5	3	0	1	1	0	14	6	30	5	0	0	0	1	11	12	30	25	5
Jalowrie,..	17	3	0	0	3	1	10	4	0	0	0	0	1	1	14	6	22½	0	0	0	1	3	5	9	20	75	90
Nareillee, ...	12	8	0	0	16	0	0	0	0	0	0	0	4	0	20	0	20	15	0	0	0	3	5	8	0	15	25
Googra, ...	18	2	0	0	18	2	0	0	0	0	0	0	0	0	18	2	10	12	0	0	0	1	3	4	0	5	15
Akhurrie, ...	13	7	0	0	11	2	0	0	1	0	0	0	4	2	16	4	27½	25	0	0	3	2	6	11	0	35	45
Chacheawas, ...	18	2	0	0	12	1	0	0	1	0	0	0	4	2	17	3	12½	28	0	0	0	0	5	5	5	10	20
Mohurwatee, ...	17	3	0	0	10	1	1	0	5	1	1	0	0	1	17	3	15	0	0	0	0	1	5	6	5	10	10
Boorhee Pokhur, ...	16	4	0	0	16	2	0	0	0	0	1	0	1	0	18	2	15	17	0	0	1	3	2	6	0	15	15
Sirhadana, ...	17	3	2	0	9	3	0	0	2	1	0	0	1	2	14	6	22½	20	0	0	0	0	9	9	5	20	35
	233	47	9	3	149	17	17	6	30	6	8	1	24	10	237	43	16	18	0	0	0				7½	21	27

[True Abstract] (Signed) W. E. BAKER, Major
and President.

APPENDIX K.

~~COPY.~~

FROM N. COLLYER, ESQUIRE,

Assistant Surgeon Mhairwara Local Battalion.

TO MAJOR W. E. BAKER,

President Canal Committee.

Dated, Beawr, 4th February, 1847.

SIR,

I have the honor to forward for your information the accompanying statement of an examination of 12 villages conducted by me in accordance with the prescribed form contained in your letter, dated 11th December, 1846; and I beg to state that for the purpose of investigation I have selected those villages which have the largest tanks and the most extensive irrigation. I am sorry to state that I have not succeeded in procuring the full complement of children, from their parents having taken them away into the jungle at hearing of my presence, being influenced, I suppose, by fear or prejudice through ignorance of the cause for which I required their presence. I trust however that the number of children contained in my report will be found sufficient to indicate the general healthiness of the district and its freedom from ague and spleen.

The general character of the cultivated soil in the immediate vicinity of the hills is of a dark, rich, loamy description, and very productive. It consists of disintegrated mica, schist, and felspar, combined with decomposed vegetable matter and salts of alumina, silica, and potash, with oxide of iron. In other parts it is of a lighter kind, and abounds with aluminous and cretaceous marls. It is of a highly absorbent nature, the surface of the land quickly becoming dry after the heaviest falls of rain. The surface of the irrigated parts inclines naturally from the bed of the tulao.

The rain crops consist of Bajra, Til and Moong with Moth, and are sown without manure in June, and likewise Mukka, Tobacco and Cotton, which are manured.

The rubbee cultivation commences at the end of October, and consists of Wheat, Barley, Gram, Sursoo and Opium; and such as are irrigated, if they escape the severe frosts and hail storms, yield a plentiful crop. Irrigation commences in November, and is continued until the end of February or beginning of March.

On the secession of the water the land is ploughed up as soon as it can be worked, and sown with the rubbee crop until the 15th of December. Such portion of the bed of the tank as becomes available for cultivation is sown during the months of February, March and April with Mukka. Thus the inconveniences likely to arise from the gradual drying up of the soil is obviated by its being immediately sown with corn. In view to increase the subsistence of the people the water-rut is freely cultivated on the surface of various of the tulaos, and without any apparent detriment to health. Moist swampy ground abounding with a variety of coarse grasses, and covered with a saline efflorescence (impure sub-carbonate of soda) prevails very generally on the rear of the embankments of all the tulaos.

The diet of the inhabitants consists chiefly of Barley and Mukka with Dal of Moth, Moong, Lobya and Oorud; they are clothed in coarse cotton cloths, and appear very cheerful and contented.

It is a characteristic of the Mhairs that they always locate their villages on heights: hence in a measure may be attributed their general good health.

From about the 15th January to the end of September the prevailing wind is from the south-west. During this period it generally blows strong and steady. During the remaining portion of the year, should any wind blow, it is from the east.

The hills in Mhairwara are all of the primitive formation, and embrace all the varieties of rocks usual under such circumstances: they are principally formed of granite, having separate beds of mica quartz, felspar with hornblende and veins of granular limestone; gneiss is in great abundance, and is used for slabbing the roofs of houses.

The depth of the soil varies greatly in different situations. It is formed of the debris of the hills, mixed up with decomposed vegetation. As a consequence, it is deeper in the vallies than on the slopes of the hills; the greatest depth may be taken at 10 feet, while in other places it is restricted to a slight covering of only a few inches.

In conclusion, I would beg leave to remark that from the observations I have made and from information I have gleaned from other sources, the impression on my mind is that hitherto no deleterious effects have arisen affecting the health of the inhabitants of Mhairwara either from the large bodies of water which have been collected by the tanks, or from the use of that water while being employed largely for the purposes of irrigation.

I have the honor to be, &c.,

(Signed) N. COLLYER, *Assistant Surgeon,*
Mhairwara Local Battalion,
In Medical charge.

Mhairwara,
Beawr, the 4th February, 1847.

(True copy)

(Signed) W. E. BAKER, MAJOR,
President Canal Committee.

ABSTRACT of Medical Examinations alluded to in the foregoing Report.

Villages.	Children of all Classes.		Adults.														Per centage of adults having suffered from fever in			Per centage of enlarged spleens.	Depth of water below the surface of ground.	Detail of sizes of enlarged spleens.					
			Brahmins, Fakeers, &c.		Hindoo Cultivators.		Mussulman Cultivators.		Bunnias.		Artizans, &c., &c.		Menials.		Totals.												
	N	E	N	E	N	E	N	E	N	E	N	E	N	E	N	E	1844	1845	1846		Feet.	VL	L	M	O	S	Total.
Dilwara, ...	20	0	1	0	8	0	0	0	2	0	4	1	3	1	18	2	0	5	40	5	2	0	0	0	1	1	2
Bulhar, ...	20	0	0	0	13	2	1	0	1	0	2	0	1	0	18	2	0	5	15	5	6	0	0	0	1	1	2
Purvrish, ...	10	0	0	0	10	0	0	0	0	0	2	0	7	1	19	1	0	0	10	$3\frac{1}{20}$	0	0	0	0	1	0	1
Beawr, ...	20	0	1	0	5	0	0	0	6	1	7	0	0	0	19	1	0	0	15	$2\frac{1}{12}$	18	0	0	0	1	0	1
Kullinjur, ...	20	0	0	0	16	0	0	0	1	0	2	0	1	0	20	0	10	0	0	0	6	0	0	0	0	0	0
Gohanna, ...	0	0	0	0	18	0	0	0	0	0	1	0	1	0	20	0	0	0	0	0	$7\frac{1}{12}$	0	0	0	0	0	0
Nurbudea Khera, ...	17	0	0	1	12	0	0	0	0	0	1	0	6	0	19	1	0	15	0	$2\frac{3}{20}$	6	0	0	0	1	0	1
Dewanta, ...	8	0	0	0	6	0	0	0	0	0	1	0	8	2	15	2	0	0	0	8	6	0	0	0	2	0	2
Jowaja, ...	16	1	0	0	15	0	0	0	3	0	0	0	2	0	20	0	0	0	0	$2\frac{3}{20}$	$4\frac{1}{12}$	0	0	0	0	1	1
Loosanee, .. .	15	1	0	0	9	1	0	0	1	0	4	0	5	0	19	1	$2\frac{33}{40}$	0	0	$5\frac{1}{12}$	$4\frac{1}{12}$	0	0	0	1	1	2
Kabree, ...	15	1	1	0	13	1	0	0	0	0	4	0	1	0	19	1	$2\frac{33}{40}$	$2\frac{3}{4}$	0	$5\frac{1}{12}$	$4\frac{1}{2}$	0	0	1	1	0	2
Kallee Konkur, ...	11	0	1	0	6	0	0	0	2	0	1	0	9	1	19	1	0	$9\frac{33}{40}$	0	$3\frac{1}{4}$	9	0	0	0	1	0	1
	172	3	4	1	131	4	1	0	16	1	29	1	44	5	225	12	$\frac{1}{4}$	3	$6\frac{3}{3}$	$3\frac{1}{4}$	6				0		

True Abstract.
(Signed) W. E. BAKER, Major,
President.

Dr. *Expenditure on the Canals West of the Jumna in Account*

	Original work.			*Establishment.*			*Current repairs.*			*Total.*		
	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.
As per Captain Blane's bills, from commencement up to 18th May, 1821, ...	142164	10	9½	52264	9	11	5319	13	7½	199749	2	4
As per Captain Colvin and Tickell's bills, from 19th May, 1821 to 30th April, 1822, ...	0	0	0	19095	9	4	6586	11	6	25682	4	10
As per ditto ditto bills of 1822-23,	0	0	0	27612	15	6	9303	2	3	36916	1	9
As per ditto ditto bills of 1823-24,	0	0	0	43815	5	7⅓	6743	10	6	50559	0	1⅓
As per ditto ditto bills of 1824-25,	0	0	0	53381	2	5⅔	4181	12	5	57562	14	10⅔
As per ditto ditto bills of 1825-26,	0	0	0	59029	9	2⅓	4580	4	5	63609	13	7⅓
As per ditto ditto bills of 1826-27,	4141	10	0	64484	13	2	6830	12	5	75457	3	7
As per Captain Colvin's bills of 1827-28, ...	18145	9	10	73141	7	7	7288	13	8½	98575	15	1½
As per ditto ditto bills of 1828-29,	0	0	0	74216	1	1	9661	9	1	83877	10	2
As per ditto ditto bills of 1829-30,	4938	14	0	74851	15	7	10435	9	3	90226	6	10
As per ditto ditto bills of 1830-31,	0	0	0	77121	1	1	16252	14	2	93373	15	3
As per ditto ditto bills of 1831-32,	0	0	0	79718	14	7	20401	5	11	100120	4	6
As per ditto ditto bills of 1832-33,	0	0	0	82242	5	7	22959	8	5	105201	14	0
As per ditto ditto bills of 1833-34,	72010	15	4	81100	0	3	21402	14	8	174513	14	3
As per ditto ditto bills of 1834-35,	90278	8	8	77646	8	4	36165	5	3	204090	6	3
As per ditto ditto bills of 1835-36,	622222	9	3½	78949	5	0	25657	8	6½	726829	6	10
As per Lieut. Baker's bills of 1836-37, ...	3383	7	8	65492	5	5	21892	14	10½	90768	11	11½
As per ditto ditto bills of 1837-38,	31743	2	1	58727	7	2	34804	7	4	125275	0	7
As per ditto ditto bills of 1838-39,	46044	0	11	57201	10	4	21073	11	5	124319	6	8
As per ditto ditto bills of 1839-40,	5562	14	0	54855	13	10	27758	0	8	88869	12	6
As per Captain Baker's bills of 1840-41, ...	31181	1	7	57066	8	5	25785	11	3	114033	5	3
As per ditto ditto bills of 1841-42,	12120	15	9	55425	14	8	28197	9	7	95744	8	0
As per ditto ditto bills of 1842-43,	25115	14	0	53104	15	11	43915	4	5	122136	2	4
As per ditto ditto bills of 1843-44,	8408	11	9	59721	3	0	31712	15	9	99842	14	6
Total cost up to end of 1843-44,	1118156	1	8	1480267	11	0⅓	448912	7	5	3047336	4	1½
As per ditto, 1844-45,	2639	6	3	67069	11	3	89689	14	5	159399	0	0
As per ditto, 1845-46,	17184	0	5	68238	1	4	62559	2	4	147981	3	11
As per ditto, 1846-47,	56769	6	4	71859	4	0	53976	10	6	182605	4	11
Total cost up to end of 1846-47,	1194748	14	8	1687344	11	7⅓	656138	2	8	3537321	12	11⅓

Current with direct Canal Revenue derived thereupon. Cr.

	Water rent on land irrigation.			*Rent on the water mills.*			*Rent on cattle watered.*			*Rent for rafting timbers.*			*Sale of the Canal produce and all sundry rents.*			*Fines for breach of Canal regulations.*			*Total direct Revenue.*		
	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.
Previous to 1820,	876	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	876	4	0
1820-21,	14646	2	1	0	0	0	0	0	0	14	4	0	635	11	0	504	8	5	15800	9	6
1821-22,	24618	8	11	0	0	0	0	0	0	84	4	0	1180	9	4	911	8	2	26794	14	5
1822-23,	21458	5	0	3026	13	6	0	0	0	0	0	0	741	7	11	1039	2	10	26265	13	3
1823-24,	36015	6	1	6868	10	0	0	0	0	0	0	0	656	0	10	1882	3	8	45422	4	7
1824-25,	26646	9	7	3964	5	4	0	0	0	0	0	0	545	7	7	1082	8	8	32238	15	2
1825-26,	48374	6	9	2991	3	11	0	0	0	0	0	0	370	9	9	2423	4	4	54159	8	9
1826-27,	33975	0	0	3682	13	2	0	0	0	500	4	0	713	13	11	3283	1	6	42155	0	7
1827-28,	34160	14	7	11676	10	9	0	0	0	1013	1	10	1460	13	9	4471	1	9	52782	10	8
1828-29,	52952	10	7	16267	0	6	3772	10	8	1187	1	10	1289	8	8	2847	6	2	78316	6	5
1829-30,	53375	0	0	19786	3	0	3568	7	10	1932	10	4	1142	15	4	2801	12	4	82607	0	10
1830-31,	57700	0	5	19464	0	0	2968	12	2	2132	8	4	1265	4	8	2508	9	6	86039	3	1
1831-32,	51016	4	11	19002	3	7	4210	9	7	2061	15	0	2127	7	0	2463	2	10	80881	10	11
1832-33,	65804	11	3	19238	2	3	3396	2	5	1611	8	7	2651	2	11	3410	4	5	96111	15	10
1833-34,	148783	2	6	13882	4	6	1257	3	11	2950	1	6	3894	6	11	6064	11	3	176831	4	7
1834-35,	114065	8	3	18294	9	9	1669	6	7	3238	9	5	3682	2	10	4303	2	10	145253	17	8
1835-36,	110602	11	3	22837	3	7	2145	15	6	1993	9	0	4957	11	9	2603	13	4	145141	0	5
1836-37,	153176	15	1	26894	10	5	2197	1	7	3365	0	0	2245	6	0	2930	5	3	190809	6	4
1837-38,	272377	13	5	5782	0	9	760	3	6	6048	9	5	5221	8	8	9480	8	9	299670	12	6
1838-39,	189644	15	3	9732	7	10	1838	15	3	8228	11	4	6171	4	2	5783	12	0	221400	1	10
1839-40,	224382	15	3	14566	8	3	2286	13	2	6579	5	1	4822	14	10	6188	2	2	258826	10	9
1840-41,	225817	15	3	9524	0	6	1955	13	2	9730	4	3	5481	6	0	6077	13	0	288587	4	2
1841-42,	263068	13	0	8203	14	3	1554	1	8	11505	15	3	5607	3	7	4632	9	6	294572	9	3
1842-43,	279300	10	11	9882	11	9	1172	5	2	7934	14	9	6756	12	3	6218	1	0	311265	7	10
1843-44,	260555	8	9	12598	13	0	1680	4	9	5570	12	6	4827	5	2	5760	14	3	290993	10	5
	2793397	5	1	278167	6	7	36434	14	11	76837	6	5	68449	2	10	89672	7	11	3343804	11	9
1844-45,	231022	8	9	8220	6	3	2979	7	2	6598	10	8	5149	11	1	6341	3	2	260311	15	1
1845-46,	260693	13	2	13250	7	11	2293	3	3	7830	0	4	7056	0	1	7753	4	6	298876	13	3
1846-47,	262529	13	8	14709	15	5	1687	0	0	6799	9	1	10167	10	4	6991	2	9	302885	3	3
	3547643	8	8	43394	9	4	43394			98911	10	6	90822	8	4	110758	2	4	4205878	11	4

Dr. *Expenditure on the Dooab Canal in Account Current*

	Original work.			*Establishment.*			*Current repairs.*			*Total.*		
	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.
As per Captain Smith's Bill from commencement to 31st December, 1830, ...	311239	12	4½	122831	0	6	0	0	0	434070	12	10½
As per Captain Cautley's audited bills from 1st January to 30th April, 1830, ...	0	0	0	3924	12	0	0	0	0	3924	12	0
Ditto ditto of 1830-31, ...	0	0	0	29658	10	2¾	3958	1	9 11/12	33616	12	8
Ditto ditto of 1831-32, ...	12022	4	9¼	47905	11	2½	4476	0	9¼	64404	0	9
Ditto ditto of 1832-33, ...	11153	7	5	27870	5	9	10929	13	0½	49953	10	2½
Ditto ditto of 1833-34, ...	19370	13	10	31767	14	5	20517	13	0½	71656	9	3½
Ditto ditto of 1834-35, ...	40256	10	6	30999	10	7	24295	8	3½	95551	13	4½
Ditto ditto of 1835-36, ...	36583	7	0	29870	1	11	24234	8	0	90688	0	11
Ditto ditto of 1836-37, ...	26599	7	10	41044	4	8	30274	0	5½	97917	12	11½
Ditto ditto of 1837-38, ...	8744	8	10	32727	8	0	24909	11	5	66381	12	3
Ditto ditto of 1838-39, ...	33208	1	10	33820	2	1	33453	9	9	100481	13	8
Ditto ditto of 1839-40, ...	1138	14	6	33462	7	10	40518	8	4	75119	14	8
Total cost up to end of 1839-40, ...	500317	8	10½	465882	9	2¼	217567	10	11 1/6	1183767	11	11 11/12
Ditto ditto of 1840-41, ...	25168	5	8	34479	2	0	34642	5	1	94289	12	9
Ditto ditto of 1841-42, ...	99396	10	3	34794	10	1	30644	11	9	164836	0	1
Ditto ditto of 1842-43, ...	10609	4	9	33971	13	9	37740	2	7	82321	5	1
Ditto ditto of 1843-44, ...	119605	1	3	31230	7	1	35876	7	11	186712	0	3
	755096	14	9½	600358	10	1¼	356471	6	3 1/6	1711926	15	1 11/12
Ditto ditto of 1844-45, ...	30385	2	5	30738	11	0	30931	12	1	92055	9	6
Ditto ditto of 1845-46, ...	11427	0	0	33900	10	8	34054	2	6	79381	3	2
Ditto ditto of 1846-47, ...	17683	2	1	34588	9	0	38800	7	9	91072	2	10
Total cost up to end of 846-47, ...	814592	3	3½	699586	8	9¼	460257	12	7 1/6	1974436	8	7 11/12

with direct Canal Revenue derived thereupon. Cr.

	Water rent on land irrigated.			*Rent on the water mills.*			*Rent on cattle watered.*			*Rent for rafting timbers.*			*Sale of the Canal produce and all sundry Rents.*			*Fines for breach of Canal regulations.*			*Total direct Revenue.*		
	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A.	P.	Co.'s Rs.	A	P.
1830-31,	6083	5	9	884	12	5¾	2	4	4½	0	0	0	592	15	3	730	0	3½	8293	6	1¾
1831-32,	7551	2	2	2476	10	2	107	3	2	9	7	9½	606	6	2	1209	0	8	11959	14	1½
1832-33,	22107	0	0	4902	15	10¾	83	14	5	11	12	3½	665	7	7½	1075	13	0	28846	15	2¾
1833-34,	46964	15	2	4435	13	4½	52	5	6½	7	5	2½	773	11	8	1270	1	5	53504	5	4½
1834-35,	37918	5	6	3335	6	5	100	12	5	0	0	0	815	15	5¼	1250	12	1	43421	3	10¼
1835-36,	37081	5	3	4728	0	7¼	63	13	0	0	0	0	1034	9	4	1325	1	4	44232	13	6¼
1836-37,	44308	6	0	5154	11	2½	61	10	0	88	12	4½	1168	5	2	735	10	7	5151	7	7·4
1837-38,	91315	9	1	5001	6	9	169	13	0	262	3	0	1222	5	2	2847	14	6	100839	3	6
1838-39,	73014	15	10	4358	4	6	104	0	0	426	8	1	1073	9	1	2967	13	0	81945	2	6
1839-40.	78543	9	11	4288	4	2	65	14	0	566	12	7	1282	8	0	3812	6	9	88559	7	5
	444888	10	8	39566	5	6¾	831	9	11	1372	13	4	9235	12	10¾	17224	10	7½	513119	15	0
1840-41,	89135	14	6	3297	9	2	97	14	0	0	0	0	2470	0	5	4322	8	11	99323	15	0
1841-42.	78885	8	5	5733	12	6	153	14	0	963	2	11	1645	3	5	3785	6	1	91164	15	4
1842-43.	107064	0	8	6194	0	9	32	10	0	522	2	8	1940	7	6	3683	0	3	119436	5	10
1843-44.	86147	1	3	8178	13	0	137	4	0	351	5	11	1413	12	9	4535	4	4	100763	9	3
	806121	3	6	62970	8	1¾	1253	3	11	3209	8	10	16705	4	11¾	38548	14	2½	923808	12	5
1844-45,	84786	2	0	6045	4	3	217	15	0	280	14	5	1704	1	11	5736	4	7	98770	10	2
1845 46,	96534	4	4	8121	15	8	103	8	0	414	10	9	1725	11	1	3086	6	11	109986	8	9
1846-47,	107725	1	8	7838	0	6	305	0	10	609	2	1	1842	0	11	3433	6	7	121752	21	7
	1095166	11	6	84975	12	6¾	1879	11	9	4514	4	1	21977	2	10¾	45805	0	3½	1254318	11	11

General Summary of Expenditure on the Ganges Canal to 31st August, 1845.

Establishment—From commencement to 31st August, 1845, and general Superintendence from 1st September, 1843 to 31st August, 1845, ...	95285	14	1
Sundries—Including extra Draughtsmen in Superintendent's office,	4215	8	4
Excavation—Comprising about 10 miles of Canal channel completed, including the 1st annual repairs and grassing of slopes about 6 miles of Canal channel in progress and heavy excavation of shingle at site of the Myapoor Dam and Regulator also in progress, ...	377639	1	1
Masonry works—Comprising the foundations of the Myapoor Dam and regulating Bridge, rivetments of the high gravel banks adjoining thereto up to the height of 5 feet. The foundations of a bathing Ghat and the Bythuk wall at Myapoor. The road and inlet Bridges of the Bochna nulla, workshops at Myapoor, model room and offices and range of Smith's and Carpenter's shops; Store rooms, &c., at Roorkhee, 1st class chokies at Myapoor, Muhmoodpoor and Belra and 2nd class chokies at Munglour, Dimat and Toghulpoor, (not including cost of bricks used in them),.....	18585	11	6
Brick making—Comprising the preparation of Government and contract kilns, as near the site of the principal masonry works as fuel could be obtained. Many of the kilns have totally or partially failed, and those of last year having not yet been unstacked, the precise number of serviceable bricks is not known, but may be roughly estimated at two hundred lacs,	119318	0	1
Workshops and purchase of store materials, such as lime, iron, stone, &c., ...	36460	0	9
Bullocks—Cost of maintaining to be charged hereafter to the works on which they were employed, ...	2418	3	2
Compensation—For land and property, and remission of land revenue, ...	5730	4	8
Grand total expenditure up to 31st August, 1845, Co.'s Rupees,	659652	11	8

Present Monthly Establishment of the Ganges Canal, (including half the expense of the Director's office, the other half being fairly chargeable to the other Canals under his superintendence), ... Co.'s Rupees, 3800 0 0

(Signed) W. E. BAKER, CAPTAIN,
Director of the Works, Ganges Canal.

Statement of the gross value of crops grown on land irrigated from the Dehlie Canals in 1837-38, *the greater part of which land would have been totally unproductive without the use of Canal water.*

KHUREEF CROPS.

		Co.'s Rs.	A.	P.
20490	Beegas of Sugar-cane and Indigo at 50 rupees per beega,	1024500	0	0
75242	Beegas of Cotton at 12 maunds of Kupas (or Cotton with seed) per beega and 16 seers of Kupas per rupee,	2257200	0	0
74010	Beegas of Rice, Jowar, &c., @ 15 maunds per beega, and 25 seers per rupee or 24 rupees per beega, ...	1776240	0	0

RUBBEE CROPS.

19000	Beegas of Wheat, Barley, Gram, Mustard, &c., &c., at 15 maunds per beega, and 20 seers per rupee or 30 rupees per beega, ...	9570000	0	
	Company's Rupees,.....	14627940	0	0

In the above statement the produce per beega is stated at the lowest average of the statements I have collected from Zemindars of the produce of their fields, and will not be considered more than might be expected from land well cultivated and plentifully irrigated. The valuation is also lower than the market prices have been within my experience during the last six months. Of this sum of 146 lacs of rupees about 1-10th is recovered by Government on account of land tax and water-rent; the remainder covers the expenses of cultivation and provides maintenance for the population of near 500 villages.

(Signed) W. E. BAKER, LIEUT.,
Superintendent Canals.

Dated,
1838.

APPENDIX C

Quarterly System of Accounts and Bills as practised on the Ganges Canal.

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The accompanying papers are drawn up so as to represent the entire working of a Quarter's accounts of a Division and consist of the following papers:—

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Appendix A.

The Daily Cash Account of the Division.

This paper scarcely needs remark as it is sufficiently explanatory in itself. It is similar to that used in all Offices of Account - it should be kept neatly and carefully and duly posted every day, and should show clearly all the cash transactions of the Divisional Office - it is debited with all Cash received from the Government Treasuries and credited with disbursements to Subordinates in charge of Sub-Divisions and Contractors Agents &c. with whom the Superintendent deals largely for the purchase of Stores &c.; all petty purchases of materials being made by the Subordinates in charge of Sub-Divisions. This account should be closed and balanced regularly on the 1st of every month and handed into the Superintendent who, after satisfying himself of its correctness, signs it, noting the balance in hand in letters as well as figures, and marking off each item in the account in the red ink character that will be described hereafter.

Appendix X.

These papers exhibit the forms of accounts submitted by the Subordinates in charge of Sub-Divisions, each months accounts being supposed to be that of a separate Sub-Division, though for convenience sake the materials in them are used to make up a Quarterly Bill

for

for one work only, which Bill being the largest and most detailed in the Series of Bills periodically Submitted I selected as the most illustrative of the System. On the receipt of the Sub Divisional papers, the Head Clerk of the Office examines them carefully corrects any errors that may exist and, this being done, he returns them to the Superintendent who proceeds to mark off each item in Characters to be noticed presently, and which Characters show the Head Clerk distinctly to what Heading in the Office Accounts every item belongs. There are other periodical papers, independently of those illustrated, which are Submitted from the Sub-Divisions, such as monthly and Quarterly Store Reports, Detailed Progress Reports, Abstracts of Accounts &c &c, but, as these are not indispensable to the illustration of the System of accounts, I have not thought it necessary to introduce them here. On the receipt of all the monthly papers back again from the Superintendent, and duly marked off, the Head Clerk proceeds to draw up his monthly papers as follows.

Appendix B.

This is an Office Account Current between the Sub-divisional Subordinate and the Superintendent. It differs only from the Subordinates own Account Current in so far that in the latter the Subordinate debits himself only with Cash received from the Superintendent and credits himself only with the cost of Labor expended on his works as well as with expenditure for the petty purchases of materials &c; whereas in the former he is debited with the value of all materials delivered into his charge and credited with the entire value

of

of work executed including the cost of both Labor and Materials. This has been found a very convenient method of Procedure inasmuch as it saves the Office much labor and valuable time, and although it entails a very small amount of extra labor (2) on each individual Subordinate, that extra labor is amply compensated for in the information it gives the Subordinate of the actual cost of the work done which he could never possess, did he not know and calculate the cost of all the materials expended upon his works - This System enables the Superintendent also, when going over his Subordinates accounts, to detect any extravagant expenditure and to correct it, or to observe where work is being economically carried out and to bestow praise on the Subordinate so doing, which he could not have done had he to wait for a month or two until the accounts were completed in the Office. The Subordinates are supplied periodically with lists of the current rates to be charged for materials; these rates are average ones, being struck quarterly or half yearly as most convenient or most needed - The Subordinates then, when entering the quantities of materials expended, carry out their cost also and thus exhibit in their Daily Reports the cost in Labor and Materials of all works executed during the month.

Appendix. C.

This is a Divisional Account Current showing at one view the sum of the transactions of the Sub-Divisions and the Office during the month. It is debited with

with all Cash received from Government and is credited with the Cost of all work executed and purchases &ca made throughout the Division during the month.

Appendix Y.

This an abstract of the Sub-divisional Daily Accounts showing the total expenditure during the month, in Labor, Materials &ca, under each of the Headings of Original Works, Stores, Executive Officer of Materials (Mr. Finn), Sundries, Tools, Current Expenses and any other Specific Headings the Superintendent may adopt, and from this paper all these items are debited off to their respective places in the Books, which are in three Volumes; viz:-

Original Works Account Book — Appendix — E.
Stores Account Book — Do — F.
Miscellaneous Account Book — Do — G.

We now come to the method adopted by the Superintendent in dividing off his Accounts to their separate Headings, and the Characters used to distinguish them, which are simple enough - They are always represented in red ink, to distinguish them from the rest of the writing, and are as follows - any letters being used that may be convenient.

A. Excavation.
1. Head Digging.
2. Contract Do.
3. Rutmoo Do.
4. Peranthulloar Do.
5. Allufinggun Do.
&ca. &ca. &ca.

B. Bridges.
1. Kunkhul Bridge.
2. Sowalapoo Do.
3. Ronkie Do.
4. Peranthulloar Do.
5. Muhenoor Do.
6. Synatoo Do.

C. Solani Aqueduct.
1. Coffer Dam.
2. Contingencies.
3. Masonry Aqueduct.
4. Earthen Do.
5. Solani Cuts & bunds.

R. Rutmoo Works.
1. Dam.
2. Inlet.
3. Revetments.
4. Regulating Bridge.
5. Cuts and bunds.
6. Pt. Class Chokie.

M. Stores.
1. Timber account.
2. Brick do.
3. Lime do.
4. Charcoal do.
&ca &ca &ca

Miscellaneous
F. Mr. Finn's account
S. Sundries' Do.
T. Tool Do.
N. Current Expended
1. Establishment.
2. Ordinary Repairs
&ca &ca &ca

The accounts being all properly prepared for entry, the several items of Expenditure and Receipts are duly posted to their respective pages of account under the Headings just described, the first of which

Appendix E.

(4

is a very simple and useful account Book, and is that from which the Superintendent makes out his Bills. It consists of 2 pages to each Work or Heading; the first of which contains the debits and Credits to the account, (the former being posted from the Abstract Book and the latter from the Bill Book). The second page is a very useful appendage, and makes the whole a very valuable and complete record, as it shows, at once, the nature of all the items of expenditure, the work done and the nature of it, for each individual item- and it enables the Superintendent to take up the Book and make out his Bills without any trouble or reference whatsoever. It possess moreover the value of making the account perfectly clear to anybody

Appendices F and G.

are filled in, in the same way, with exception to the detailed explanation of debits, which may or may not be kept as the nature and extent of the transactions may demand, it being decidedly advisable to maintain the detailed explanation whenever the accounts are heavy and extensive. The Store accounts get credit for the materials expended on the Works, and the Miscellaneous accounts get their credits as the state of his Works and Accounts enable the Superintendent to adjust them. These Miscellaneous accounts may all be called fluctuating

accounts

accounts with exception to the Current Expense Accounts which are adjusted by monthly Current Bills.

Appendix H.

Is a check Book - which it is necessary to keep to enable the Head Clerk to determine the correctness of his account. it is kept on the System of Double Entry and needs no explanation, being a repetition in as abstract a form as possible of the former papers - the debits and credits of every account agreeing exactly with each other. The Balance Sheet of this Check Book shows at a glance the state of the affairs of the Division, and being closed, the Head Clerk can at once make up his General (Salary) Account Current - given in - Appendix D.

This Account Current is however submitted only Half Yearly - it is submitted to the Accountant North Western Provinces by whom it is checked - and any errors that may exist are officially notified to the Superintendent for correction. This account is debited with all charges made by the Government against the Division either for cash or Stores supplied from the different Government Departments - and is credited only with Bills duly audited; the way in which the Balance unaudited or unaccounted for is disposed of being explained under the Head of Inefficient Balance.

Roorkee.
19th March. 1854.

C Scanlan.
Accountant Director's Office
Ganges Canal Works.

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Appendix A.

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Day Book. #1

Cash account Particulars.

Northern Division Ganges Canal. Vital

Daily Particular Cash Account of the Northern Division of the Ganges Canal.

Date		Description.	Received.			Exp
1853. February	1	Camp. Mukeewur.				
		To Balance of last account	10.000	"	"	
		To Cash received from the Collector of Saharunpoor in lieu of Assignment (No 10 of 1852/53 dated 15th ultimo) drawn by the Accountant N.W.P. on the Saharunpoor Treasury	75.000	"	"	
"	2	Camp Mukeewur.				
		Advanced to Ramsook Contractor for Buhera Timber	"	"	"	20
		Advanced to Mr. Finn Executive Officer of Materials	"	"	"	20.0
"	15	Camp. Roorkee.				
		Amount remitted to Overseer	"	"	"	5.0
		Advanced to Mr. Finn Executive Officer of Materials	"	"	"	20.0
	25	Amount remitted to Overseer	"	"	"	4.0
		Advanced to Mr. Finn Executive Officer of Materials	"	"	"	20.0
"	28	Advanced to Ramjus Contractor for the purchase of Sal Timber	"	"	"	5.0
		Totals	85.000	"	"	76.0
		Balance in hand	"	"	"	9.0
		Grand Total — Cost Rs	85.000	"	"	85.0
March	1	Camp Dhunowree				
		To Balance of last account	9.000	"	"	
"	9	Amt paid to Baldaient into Hospital Yesterday from Roorkee Banks digging being wages for 8 days @ 2 as. per day	"	"	"	
		To Cash received from the Collector of Saharunpoor in lieu of Assignment (No 12 of 1852/53 dated 25th ultimo) drawn by the Accountant N.W.P. on the Saharunpoor Treasury	75.000	"	"	
"	10	Camp Puran Nullewur				
		Amount remitted to Overseer	"	"	"	5.0
		Advanced to Mr. Finn Executive Officer of Materials	"	"	"	20.0
"	15	Camp Roorkee				
		Amount remitted to Overseer	"	"	"	10.0
		Paid Yooz of Ali Contractor Amount of his Bill for completion of Well for Aqueduct	"	"	"	3
		Carried Forward — Cost Rs	84.000	"	"	35.0

te		Description	Received			Expended		
		Brought forward from Folio 84	84.000	"	"	35.292	4	5
Nov	25	Roorkee						
		Advanced Mr. Finn Executive Officer of Materials	"	"	"	20.000	"	"
	31	Remitted to Calcutta Agents, being Amt of their Bill for purchase of Iron & Miscellaneous Metals	"	"	"	25.000	"	"
		Totals	84.000	"	"	80.292	4	5
		Balance in hand	"	"	"	3,707	11	7
			84.000	"	"	84.000	"	"
Dec	1	To Balance of last Account	3.707	11	7			
	5	Roorkee						
		To Cash received from the Collector of Saharunpoor in lieu of Assignment (No. 15 of 1852/53 dated the 23rd ultimo) drawn by the Accountant Genl. on the Saharunpoor Treasury	75.000	"	"			
	10.	Amt remitted to Dy Superintendent	"	"	"	1.000	"	"
		Advanced D. Expc. Officer of Materials	"	"	"	20.000	"	"
	15	Amt Remitted to Dy Superintendent	"	"	"	15.000	"	"
	16	Do Do Do	"	"	"	5.000	"	"
	25	Advanced to Expc: Officer of Materials	"	"	"	20.000	"	"
	31	Remitted to Dy Superintendent D pay of Regular Establishment for current month	"	"	"	41	"	"
		Do Do D pay fluctuating do do do	"	"	"	180	"	"
		Amt paid to Treasurer for 209 mds, 32 Srs, 12 chks of Gram Supplies to Horses employed on Excavation in the 15th and 16th Miles @ Yearly Contract rate of 2/- per md.	"	"	"	419	10	2
		Totals	78.707	11	7	61.640	10	2
		Balance in hand	"	"	"	17.067	1	5
		Total	78.707	11	7	78.707	11	7

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Seventeen Thousand Sixty Seven, one anna and Five.

(Sd) A.Y. Goodwyn. Captain.
Superintendent Wn. Dn. Ganges Canal.

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Appendix X

(8)

Overseer ——— 's accounts

for the month of

February 1853.

——— Overseer in account Current with the Canal for the month of February 1

Dr.:

Date		Receipts.	Amounts.	
February	1	To Balance in hand ———		
	15	To Cash received from the Superintendent ———	5.000 " "	
	25	" Do. Do. ———	4.000 " "	

...ntendent of the Northern Division Ganges Canal

Roorkee. 1st March 1853

Cr:

Expenditure.	Amount			Total.		
By Amount paid for Labor during the month of February 1853: Viz: as per Daily Account:						
No. 1 Earthwork	1,446	9	8			
" 2 Do.	1,474	13	10			
" 3 Do.	668	2	"			
" 4 Do.	1,117	8	8			
" 5 Do.	538	6	4			
" 6 Do.	190	12	3			
" 7 Do.	40	10	4			
" 8 Do.	269	"	"			
" 9 Do.	904	6	4			
" 10 Plantations	9	"	"			
" 11 Brick Kilns	10	9	4			
" 12 Do.	28	15	8			
" 13 Lime Kilns	5	"	"			
" 14 Repairs	18	15	4			
" 15 Do.	"	8	"			
" 16 Do.	5	"	"			
By Regular Establishment for February 1853	10	"	"			
" Fluctuating Do. Do.	144	11	1			
" Purchase of Country Paper	1	"	"	6884	1	"
Balance in hand				2,415	15	"
Total Costs				9,300	"	"

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Overseer.

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Total Cost on No. 16

Ganga Canal

appendix.

Sig 1 vol

Attorney

Carter

Jan

Daily Account of Expenditure on the [illegible] during the month of February 1853.

C4 C4 C4 C4 C4 C4

	No. 1. Excavation. 15th Mile. Wagons drawn by Horses.					No. 2. Excavation. 16th Mile. Wagons drawn by Horses					No. 3. Same as No. 2. Wagons propelled by Men.					No. 4. Spreading Nos. 1, 2 and 3.					No. 5. Excavation Rock & Boulders Men.					No. 6 Spreading No. 5.				
Totals.					1,816	3	5			1,967	11	"	719	12	6					1117	8	8	538	6	4			190	12	5
Amounts	1146	9	8			1474	13	10			668	2	0			117	6	10												
	800	"	"			850	"	"			659	15	9			1000	1	10												
	500	"	"	1446	9	8	550	"	"				50	"	"															
	50	"	"				10	"	"				1	10	6															
	300	"	"				10	"	"																					
	19	9	9	369	9	9	472	13	2	492	13	2																		
Date and Description	Mates @ 6/-	Bilsters @ 4/-	Spars @ 5/-	Buckets @ 2/-	Hands Loco.	Rle @ 5/-		Mates @ 6/-	Bilsters @ 4/-	Spars @ 5/-	Tallow	Buckets @ 2/-	Hands Loco		Mates @ 6/-	Bilsters @ 4/-	Buckets @ 2/-	Grease		Mates @ 6/-	Bilsters @ 4/-		Mates @ 6/-	Bilsters @ 4/-		Mates @ 6/-	Bilsters @ 4/-		
1	25	200	100	100		2	5	10	212	110	2	10			2	165	1200	x.s.c.		20	250	7/4	125			2	45			
2	25	200	100	100		4		10	226	110	2	10			2	165	"	"		20	250	7	125			2	45			
3	25	200	100	100		4		10	212	110	2	10			2	165	"	"		20	250	7	125			2	45			
4	25	200	100	100		4		10	212	110	2	10			2	165	"	"		20	250	7	125			2	45			
5	25	200	100	100		4		15	212	110	2	10			2	165	"	"		20	250	7	125			2	45			
6	25	200	100	100		4		10	212	110	2	10			2	165	"	"		20	250	7	125			2	45			
7	25	200	100	100		4		10	212	110	2	10			2	165	"	"		20	250	7	125			2	45			
8	25	200	100	100		4		10	212	110	2	10			2	165	"	"		20	250	7	125			2	45			
9	25	200	100	100		4		10	212	110	2	10			2	165	"	"		20	250	7	125			2	45			
10	25	200	100	100		4		15	212	110	2	10			2	165	"	"		20	250	7	125			2	45			
11	25	200	100	100		4		20	212	110	2	10			1	165	"	"		20	250	7	125			2	45			
12	25¾	200	100	100		3		20	212	110	2	10			1	165	"	"		20	250	6	125			2	45			
13	24	200	100	100		8		15	212	110	1	10			1	165	"	"		20	250	6	125			2	45			
14	24	200	100	100		8		20	212	110	1	10			1	165	"	"		20	250	6	125			2	45			
15	24	200	100	100		8		15	212	110	1	10			1	165	"	"		20	250	6	125			2	45			
16	24	200	100	100		8		20	212	110	1	10			1	165	"	"		20	250	6	125			2	45			
17	24	200	100	100		8		10	212	110	1	10			1	165	"	"		20	250	6	125			1	45			
18	24	200	100	100		8		19½	212	110	1	10			1	165	50	"		20	250	6	125			2	45			
19	24	200	100	100		8		10	212	110	1	10			1	165	"	"		20	250	6	125			2	45			
20	24	200	100	100		8		10	212	110	1	10			1	165	"	"		20	250	6	125			2	45			
21	24	200	100	100		8		10	212	110	1	10			1	165	"	"		18	250	6	125			2	45			
22	24	200	100	100		4		10	212	110	1	10			1	165	"	"		18	250	6	125			2	44			
23	24	200	100	100		4		10	212	110	1	10			1	165	"	"		18	250	6	125			2	44			
24	24	200	100	100		4		10	212	110	1	10			1	165	"	"		18	250	6	125			2	44			
25	24	200	100	100		11		10	212	110	1	10			1	165	"	"		19	250	6	125			2	44			
26	24	200	100	"		4		10	212	110	1	"			1	165	"	"		19	250	6	125			2	44			
27	24	200	100	"		9		10	212	110	1	"			1	165	"	"		19	250	6	125			2	44			
28	24	200	100	"		9		10	212	110	1	"			1	165	"	"		19	250	6	125			2	44			
	681½	5600	2800	2500		1.0.0		349½	5950	3080	1.0.0	250			38	4620	1250	0.6.10		548	7000¾	179¼	3500			55		12.5.3		
Total Cost on No. 1								Total Cost on No. 2							Total Cost on No. 3					Total Cost on No. 4						Total Cost on No. 5				

5,00,966 C.ft of Earth excavated, filled into Ballast Wagons and propelled along Railway by horses an average distance of 8540 feet and emptied by tip & Railway.

3,99,300 C.ft of Earth excavated & as in the foregoing an av. distance of 11555 feet and emptied as before.

2,02,112 C.ft of Earth as before - average distance being 7,000 feet.

11,02,378 C.ft of Earth spread in Channel

1,94,525 C.ft as before, but propelled by Men average distance being of 5000 feet.

The foregoing quantity spread in Channel.

...ned Works of the Northern Division Ganges Canal

Roorkee. 1st March. 1853.

| | | |

Pay Bill of Establishment attached to the Northern
vision of the Ganges Canal during the month of February 1853

Roorkee 1st March 1853.

ription	Names	Amounts			Total			Nature of Establishment
ddi	Syam				10	"	"	Permanent.
i	Kulloo	20	"	"				
ddi	Jaffer Ali	15	"	"				
	Bridj-lal	8	"	"				
	Saadut Ali	7	"	"				
raiee	Kulloo	5	"	"				
	Jehangeer Khan	5	"	"				
	Sahib Sing	5	"	"				
	Hera Sing	5	"	"				
	Sinee	5	"	"				
	Doolutram	5	"	"				
	Debee Singh	5	"	"				
	Ruttun Singh	5	"	"				
	Kadirbux	5	"	"				
	Bhoput	5	"	"				
ee	Lalla	4	"	"				
	Dree	4	"	"				
	Debee	4	"	"				
	Garao	4	"	"				
	Kwajoo	4	"	"				
	Doonda Khan	4	"	"				
	Sallee	4	"	"				
	Gunga Ram	4	"	"				
	Ram lal	4	"	"				
	Poorun	4	"	"				
	Ramdeen	4	"	"				
	Debeedeen @4/- 5 days-	"	11	1	144	11	1	Fluctuating
Total ~~Rs~~		15		6	154	11	1	10½

(12)

above men were all paid in my Presence.

(Sd/)

Overseer

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(67)

Appendix. X.

Overseer ——————'s Accounts
for the month of
March 1853.

(113

Overseer in account Current with
Ganges Canal for the month of March

Dr.

Date.		Receipts.	Amount	
March	1	To Balance in hand		5
	10	To cash received from the Superintendent	5,000 " "	
	15	" Do. Do. Do.	10,000 " "	15
		Total Rs		20

4 12 6

Superintendent of the Northern Division of the

Roorkee. 1st April. 1853.

(14 Cr:

Expenditure.	Amount.	Total.
By Amount paid for Labor during the month of March 1853 as per Daily Account: Vizt:		
Nos 1 Earthwork	8038 10 8	
2 Do.	2805 3 10	
3 Do.	3842 " 3	
4 Do.	42 2 "	
5 Do.	37 11 "	
6 Do.	802 4 5	
7 Do.	477 10 8	
8 Do.	212 " "	
9 Do.	151 " 4	
10 Do.	221 13 11	
11 Do (dressing Slopes)	100 " "	
12 Plantations	1 15 8	
13 Brick Kilns	1 15 8	
14 Lime do	1 3 "	
15 Charcoal do	1 3 "	
16 Do. Do.	" 12 8	
17 Masonry	18 8 6	
18 Sundries	20 " "	
By Regular Establishment for March 1853	10 " "	
" Fluctuating Do Do	144 " "	
" Purchase of Country Paper	2 " "	
" Repairs of Banks (Contract) 20 Miles @ 30/- per mile	600 " "	17532 3 7
Balance in hand		2467 12 5
Total Cost Rs		20,000 " "

(Sd) 18 6 6

Overseer

(68.69)

Daily Account of Expenditure on the under
during the month of March. 1853.

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Date and Description	No. 1. Excavation. 15th Mile.						No. 2. Excavation. 16th Mile.						No. 3. Spreading Nos 1 & 2.						No. 4. Excavation 16th Mile.	No. 5. Excavation. 17th Mile.	No. 6. Excavation Rookee Bank.	No. 7. Spreading Nos 5 and 6.	No. 8. Removing Earth already deposited.
	Masters @ 6/-	Bildars @ 4/-	Sykes @ 5/-	Horses Trucks Barrows @ 4/-	Spades	Amounts	Masters @ 6/-	Bildars @ 4/-	Sykes @ 5/-	Horses Trucks Barrows	Spades	Amounts	Masters @ 6/-	Bildars @ 4/-	1Qs @ 2 apiece	Bildars @ 2 apiece	Amounts						
1	57⅓	1126½	640	1000	8 @ 4.12		18	550½	100				34	917	1	37		11	1	231	1	148	76
2	57	1126	640	"	"		18	550	100				34	910	1	10		10	1	206	1	121	54
3	57	1126	640	"	"		18	550	100				34	910	1	10		"	1	206	1	121	54
4	57	1126	640	"	"		18	550	100				34	910	1	10		10	1	206	1	121	54
5	57	1126	640	"	"		18	550	100				34	910	1	10		10	1	206	1	121	54
6	57	1125	640	"	"		18	550	100				34	910	1	10		10	1	206	1	121	54
7	57	1125	640	"	"		18	550	100				34	910	"	10		10	1	206	1	121	54
8	57	1125	640	"	"		18	550	100				34	910	"	10		10	"	206	1	121	54
9	57	1125	640	"	"		18	550	100				34	910	"	10		10	"	206	1	121	54
10	57	1125	640	"	"		18	550	100				34	910	"	10		10	"	206	1	121	54
11	56	1125	640	"	"		18	550	100				34	910	"	10		10	"	206	1	121	54
12	56	1125	640	1000	4		18	550	100				34	910	"	10		10	"	206	1	121	54
13	56	1125	640	"	"		18	550	100				34	910	"	10		10	"	206	1	121	54
14	56	1125	640	"	"		18	550	100				33	910	"	10		10	"	206	1	121	54
15	56	1125	640	"	"		18	550	100				33	910	"	10		10	"	206	1	121	54
16	56	1125	640	"	"		18	549	100				33	910	"	10		10	"	206	1	121	54
17	56	1125	640	"	"		18	549	100				33	910	"	10		10	"	206	1	121	54
18	56	1125	640	"	"		18	549	100				33	910	"	10		10	"	206	1	121	54
19	56	1125	640	"	"		18	549	100				33	910	"	10		10	"	206	1	121	54
20	56	1125	640	"	"		18	549	100				33	910	"	10		10	"	206	1	121	54
21	56	1125	640	"	"		18	549	100				33	910	"	10		10	"	206	1	121	54
22	56	1125	640	"	"		18	549	100				33	910	"	10		10	"	206	1	121	54
23	56	1126	640	"	"		18	549	100				33	910	"	10		10	"	206	1	121	54
24	56	1125	640	1000	"		18	549	100				33	910	"	10		10	"	206	1	121	54
25	56	1125	640	"	"		18	549	100				33	910	"	10		10	"	206	1	121	54
26	56	1125	640	"	"		18	549	100				33	910	"	10		10	"	206	1	121	54
27	56	1125	640	"	"		18	549	100				33	910	"	10		10	"	206	1	121	54
28	56	1125	640	"	"		17	549	100				33	910	"	10		10	"	206	1	121	54
29	56	1125	640	"	⅝		17	549	100				33	910	"	10		10	"	206	"	121	54
30	56	1125	640	"	¼		17	549	100				33	910	"	10		10	"	206	"	121	54
31	56	1125	640	750	"		17	549	100				33	910	"	10		10	"	206	"	121	54
	1746⅓	34806	19840	3750	6.16.12		554	17034½	3100		6.7.8		1036	28217½	4	337		301½	7	6411	28	3778	1496
	21,30,206 C. feet of excavation from 15th Mile, filled into Ballast Wagons propelled along Railway by Horses and emptied by the Side of Railway. Av. dist. 10,760 feet.						7,55,758 C. feet of Excavation same as in the foregoing average distance being 10,775 feet.						2885.964 C. feet of Earth Spread						11,250 C. feet (single dose) carried in baskets a distance of 150 feet in a Rope of 25 feet and emptied on embankments.	12,195 C. feet from 17th Mile, propelled in Wagons by Horses average distance 3000 feet.	2890¼ C. feet from Rookee Bank No. 5 average distance 1720 feet.	30,269 C. feet of Earth spread	10,785 C. feet of earth formerly deposited in Stacks removed to embankments & spread.

Total Cost of No. 1

Total Cost of No. 2

Total Cost of No. 3

Total Cost of No. 6

Total Cost of No. 7

Works of the Northern Division Ganges Canal

Roorkee. 1st April. 1853.

No. 12. Plantations.			No. 13. Mutteewun Brick Kiln.			No. 14. Lime Kiln at Roorkee			No. 15. Charcoal Kiln at Roorkee.			No. 16. Charcoal Kiln at Mullikpoor.			No. 17. Synebas Bridge.			No. 18. Sookie.		
Teak Trees	27	0 0																		
Toons	1	" 4																		
				30	" "		28	0 4		1	3 "		"	12 8					20	" "
Coolies @ 7 Rics				1	15 8															
Oplas				48	" 4															
				50	" "															
Coolies @ 7 Rics							1	3 "												
Oplas				11	" "															
Kundeeru				13	13 "		23	13 "		23	13 "		19	3 4						
				25	" "		25	" "		25	" "		20	" "						
Coolies @ 7 Rics										1	3 "									
Koo Kur			23	12	"															
Rope			"	1	"															
Bamboos @ 9 Rics															5	5 6				
Do @ 8 do.															2	11 "				
Do @ 7 do.															"	8 9				
Kildars @ do. do.															3	8 0				
Do @ 5 do.															6	4 3				
Coolies @ 7 Rics															18	8 6				
Koo Kur			19	2	"															
Baskets			"	1	4															
Bricks															202	8 "				
Lime															57	" "				
Sookie															40	12 10				
Baskets															1	7 6				
																	295	12 4		
																	3144	10		
Contractors																			20	" "
Bricks																			112	8 "
																			132	8 "

| | | | | | | | | | | | | | | | | | | |

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(70) Set

Bill of Establishment attached to the Northern Di=
of the Ganges Canal during the month of March

Roorkee. 1st April. 1853.

Description	Names	amount			Total			Nature of Establishment
adi	Syram				10	"	"	Permanent.
i	Nullo	20	"	"				
adi	Jaffeer Ali	15	"	"				
	Bidj Lal	8	"	"				
	Saadut Ali	7	"	"				
rasee	Nullo	5	"	"				
	Dehangeer Khan	5	"	"				
	Sahib Singh	5	"	"				
	Hera Singh	5	"	"				
	Sirree	5	"	"				
	Dowlut Ram	5	"	"				
	Debee Singh	5	"	"				
	Nuttun Singh	5	"	"				
	Radinbus	5	"	"				
	Bisputh	5	"	"				
	Lalla	4						
	Oree	4						
	Debee	4						
	Garao	4						
	Kwajoo	4						
	Londa Khan	4						
	Sallee	4						
	Gunga Ram	4						
	Ram Sal	4						
	Soorun	4						
	Ramdeen	4			144	"	"	Fluctuating
16	~~Total~~ ~~15~~ ~~cost~~ Rs	6			154	6	"	10½

16

The above men were paid in my presence.

15th/ _____

Overseer

71, 72, 73

Daily Account of Expenditure on the undermentioned Works of the Northern [Division Ganges Canal during the month of April. 1853.

[L. 78; V. iii.

[Roorkee. 1st May. 1853.

(17

Nos 1 to 19 inclusive all to C.

Nº 1. Excavation Solations.	Nº 2. Clearances.	Nº 3. Solani Aqueduct Revetments. Plain Masonry.	Nº 4. Ramming &c.	Nº 5. Solani Aqueduct Revetments. Step Masonry.	Nº 6. Mowing Watering.	Nº 7. Solani Aqueduct Revetments. Main Arch Masonry.	Nº 8. Lions.	Nº 9. Lions.
291 " 3	92 11 9	5.399 14 9		2 6 5 11	284 2 15	7.703 11 9		
		39296 8 1	44.696 6 6	2.778 13 3		1.230 4 11	350 " "	603 14 6
		Total Cost of Nº 3		Total Cost of Nº 5		Total Cost of Nº 7		

Nº 1 — Nº 2 — Nº 3 — Nº 4 — Nº 5 — Nº 6 — Nº 7 — Nº 8 — Nº 9

Total Cost of Nº 1 — Total Cost of Nº 2 — Total Cost of Nº 3 — Total Cost of Nº 4 — Total Cost of Nº 5 — Total Cost of Nº 7 — Total Cost of Nº 8 — Total Cost of Nº 9

Clearing away accumulation deposited from Revetments

291.372 C.ft Masonry.
Mortar
1 Lime, 1 Sand, 1 Soorkee.

Transport of Implements Carts & Establishments employed in Cattle Sheds

1083.2 C.ft of Masonry.
Mortar.
Same as before.

48.242 C.ft of Masonry in Arches.
Mortar as before.

19.734 C.ft of Plain Masonry in Foundations & Pedestals of Lions.
Mortar as before

Bodies of Lions.
In progress.

50.000.
1200 Rounds.
2838½ Maunds.

Total cost of Nº 9

Daily Report of Expenditure on the undermentioned Works of the Northern Division Ganges Canal during the month of April. 1853.

(L.73, V.iii.)

Roorkee. 1st May. 1853.

Date	No. 10. Excavation. Bilan @ 8/	No. 11. Plastering. Mates @ 6/	Mate @ 5/	Bilan @ 4/	Lime @ 20/	Coarse @ 12/	No. 12. Excavation 15th Mile. Mate @ 6/	Bilan @ 4/	No. 13. Excavation 16th Mile. Mate @ 6/	Bilan @ 4/	No. 14. Spreading Nos 12 and 13. Bilan @ 2nd/	No. 15. Excavation 19th Mile. Bilan @ 4/	Lo @ 2 1/2/	No. 16. Excavation Roorkee Banks. Bilan @ 4/	Lo @ 2 1/2/	No. 17 Spreading Nos Bilan @ 2nd/	Mate @ 5/	Bilan @ 4/	No. 18. Filling Nos	No. 19. Solani Aqueduct Revetments. Plain and Rora Masonry. Mason @ 8/	Lo @ 7/-	Lo @ 6/-	Mate @ 6/	Bilan @ 5/	Lo @ 4/-	Brick @ 12/	Lime @ 24/	Coarse @ 12/	Rora @ 6/
	Total Cost of No. 10						Total Cost of No. 12		Total Cost of No. 13			Total Cost of No. 15		Total Cost of No. 16															
	57 4 "										321 4 "			3 9 8															
		3003 11 9					6 " "		12 " "																			
		10 " "					427 11 6		858 " 3			44 2 1		4 " "															
		1196 12 "										1 " "																
					700 " "																							
						1161 10 6																						
							6.072 2 3		870 " 3		321 4 "	44 2 1		7 9 8					312 6 "										
1	200	389	2	323			1	134		2	229½	105	12	1							75	86	100	1	3	170			
2	98	375	2	319			1	106		2	214	85	11	1	1	8					75	86	100	1	3	170			
3	"	375	2	319			1	106		2	214	85	11	1	26	30					75	86	100	1	3	170			
4	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
5	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
6	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
7	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
8	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
9	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
10	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
11	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
12	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
13	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
14	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
15	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
16	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
17	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
18	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
19	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
20	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
21	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
22	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
23	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
24	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
25	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
26	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
27	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
28	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
29	"	375	2	319			1	106		2	214	85	11	1	"	"					75	86	100	1	3	170			
30	"	375	2	319			1	196		2	214	85	11	1	"	"					75	86	100	1	3	170			
Total	298	11414		60	9574	3000	96807	30	3908		64838	2570	331	8	2.7	32					2250	2680	3000	30	90	5100	600000	15000	17346	100000
		156203 Sq feet of Pukka plaster.																												
		38032 Square feet of the above are not finished.																												

1,27,008 C.ft of Miscellaneous Masonry.
Chiefly plain-in Embankment
Mortar as before.

Signature: Lt Superintendent.

(14)

ay Bill of Establishment attached to the Northern Division
Ganges Canal Works during the month of April. 1853.

Roorkee 1st May. 1853.

Description	Names	Amounts			Total			Nature of Establishment.
								(18)
ris	Lootee	25	"	"				
hee	Koolshiab Singh	10	"	"				
prassi	Ramdeen	6	"	"	41	"	"	Permanent.
dar	Heera Singh	12	"	"				
ris	Thakondass	12	"	"				
	Ram Singh	12	"	"				
	Akbar Ali	12	"	"				
	Imam Ali	12	"	"				
shee	Deean Singh	10	"	"				
	Iftekar ali	10	"	"				
	Wuzeer Ali	10	"	"				
	Imam-ood-deen	10	"	"				
	Aman Khan	10	"	"				
prasee	Beharee Lal	5	"	"				
	Sirdar	5	"	"				
	Ellibuksh	5	"	"				
	Imambuksh	5	"	"				
	Koodhabuksh	5	"	"				
	Mahumdee Khan	5	"	"				
lee	Lylal	4	"	"				
	Ram Singh	4	"	"				
	Gungaram	4	"	"				
	Gungadeen	4	"	"				
	Nebbibuksh	4	"	"				
	Govind	4	"	"				
	Huzzaree Lal	4	"	"				
	Kuttoo Khan	4	"	"				
	Wuzeeood-deen	4	"	"				
	Sutfoolla Khan	4	"	"	180	"	"	Fluctuating.
10	Total Cost Rs	6			221	"	"	

The above men were paid in my Presence.

(5/) _____ Lieut:
Dy Superintendent.

Appendix. X.

Day Superintendent ——— 2 Accounts

for the month of

April 1853.

Lieutenant _____ Dy Superintendent in Accor
Ganges Canals for the month of April

Dr.

Date		Receipts.	Amounts
April	1	To Balance in hand _____	
	10	To Cash received from the Superintendent _____	1,000 " "
	15	" Do. Do. _____	15,000 " "
	16	" Do. Do. _____	5,000 " "

Total Rs _____

4 12 6

with the Superintendent of the Northern Division

Roorkee. 1st May. 1853

Expenditure	Amounts			Total		
By Amount paid for Labor during the month of April 1853. as per Daily Report. Viz:-						
No. 1 Earthwork	291	"	3			
" 2 Clearance	92	11	9			
" 3 Masonry	5399	14	9			
" 4 Earthwork	26	5	11			
" 5 Masonry	2778	15	3			
" 6 Arch Centres	284	2	5			
" 7 Masonry	1230	4	11			
" 8 Do.	350	"	"			
" 9 Do.	603	14	10			
" 10 Earthwork	37	4	"			
" 11 Plastering	4210	7	9			
" 12 Earthwork	433	11	6			
" 13 Do.	870	"	3			
" 14 Do.	321	4	"			
" 15 Do.	45	2	1			
" 16 Do.	7	9	8			
" 17 Do.	19	"	"			
" 18 Do.	312	6	"			
" 19 Masonry	2503	"	"			
By Well sinkers employed on Masons' well	7	"	"			
" Presents to Drivers on extra Work in Roorkee Banks	25	"	"			
" Contract carriage of Bricks at Aqueduct	500	"	"			
" Paid Contract for building Work peoples' Houses	2081	5	10			
" Purchase of Country Pens and Ink	2	"	"	22,432	9	2
Balance in hand				2567	6	10
Total cost Rs				25.000	"	"

18 6 6

(18)

Appendix B.

(21

Office Account Current with

Overseer _____

for the month of February 1853.

——— Overseer in Account Current with
Dr: Division of the Ganges Canal for the M

Date		Receipts.	Amounts	
Feby	1	To Balance of last account		
	15	To Cash received from the Superintendent	5000 " "	
	25	" Do. Do.	4000 " "	

Total Cost Rs

Roorkee.
1st March 1853.

tain A G Goodwyn Superintendent of the Northern
February 1853.

22 ber.

Expenditure.				Amounts.			Total.		
By Solani Earthen Aqueduct as per Daily Report: Vizt ———									
Expended on Nos 1 Excavation		1816	3	5					
2 Do		1967	11	"					
3 Do		719	12	6					
4 Spreading		1117	8	8					
5 Excavation		538	6	4					
6 Spreading		190	12	5					
7 Removing Sand		40	10	4					
8 Spreading		269	"	"					
9 Puddling		904	6	4			J. 564	7	"
By expense incurred on the undermentioned works as per Daily Report: Vizt: ———									
No. 10 Plantations						10	"	"	
" 11 Brick Kiln at Muhewur						20	"	"	
" 12 Do at Roorkee						50	"	"	
" 13 Lime Kiln at Myapoor						10	"	"	
" 14 Repairing Banks						20	"	"	
" 15 Iron Work of Gates						5	"	"	
" 16 Repairing Kulseea Chokie						37	4	10	
By Regular Establishment for February 1853						10	"	"	
" Fluctuating Do Do						144	11	1	
" Purchase of County paper						1	"	"	J. 872 6 11
Balance in hand									2. 127 9 1
Total Costs									10,000 " "

E. E. 18 (5 d.) 6

Head Clerk

2

~~15~~ 77

Appendix B

Office Account Current with 23

Overseer _____

for the month of March 1853.

_____ Overseer in Account Current with [illegible]

[illegible] Ganges Canal during the month of Ma[illegible]

Date		Receipts.	Amounts.	
March	1	To Balance last account		10[illegible]
	10	To Cash received from the Superintendent	5,000 " "	
	15	" Do Do	10,000 " "	15[illegible]

Total Rs _____

Roorkee.
1st April.
1853.

A. G. Goodwyn. Superintendent Northern Division of the

3.

Expenditure		Amounts.			Total.		
By St Lani Canal Aqueduct, as per Daily Report: Vizt:					24		
Expended on No. 1	Excavation	10192	13	10			
2	Do	3407	1	1			
3	Spreading	3842	"	3			
4	Excavation	42	2	"			
5	Do	37	11	"			
6	Do	802	4	5			
7	Spreading	477	10	8			
8	Removing earth	212	"	"			
9	Spreading	157	"	4			
10	Ramming	221	13	11			
11	Dressing Slopes	100	"	"	19486	9	6
By expenses incurred on the undermentioned Works as per Daily Report: Vizt:							
No. 12	Plantations	30	"	"			
" 13	Mukwow Brick Kiln	50	"	"			
" 14	Lime Kiln at Roorkee	25	"	"			
" 15	Charcoal Kiln Do	25	"	"			
" 16	Do at Mullikpore	20	"	"			
" 17	Synetias Bridge	314	4	10			
" 18	Tonkee	132	8	"			
By Regular Establishment for March 1853		10	"	"			
" Fluctuating Do Do		144	"	"			
" Purchase of Country Paper		2	"	"			
" Repairs of Banks, Contract 120 miles @ 25/- per mile		600	"	"	1352	12	10
					20839	6	4
Balance in hand					4160	9	8
Total Costs					25,000	"	"

E. E. 18 (No.) 6 6

Head Clerk

~~2~~ 78

25

Appendix B

Office Account Current with

Dy Superintendent _____

for the month of April 1853.

Lieutenant ——— Dy Superintendent in Ac
Dr Ganges Canal for the month of April. 1853.

Date.		Receipts.	Amounts.			
April	1	To Balance of last Account ———				90
	10	To Cash received from the Superintendent ——	1,000	"	"	
	15	" Do. Do. Do. ———	15,000	"	"	
	"	" 10 Lakhs of Bricks received @ 1000/- per lakh —	10,000	"	"	
	16	" 40 Do. Do. @ Do. ———	40,000	"	"	
	"	" Cash received from the Superintendent ——	5,000	"	"	
	20	" 1,00,000 Maunds of Stone Lime @ 20/- per 100 mds —	20,000	"	"	
	"	" 1,25,000 Maunds of Soorkee @ 12/ per do ———	15,000	"	"	10

Total cost Rs ——— 1

4 12 6

Roorkee.
May 1853

ent with the Superintendent of the Northern Division

[26 Cr:

Expenditure.				Amounts			Total.		
By Solani Aqueduct Revetments and Earthwork as per Daily Report: Vizt:									
Nos 1. Excavation for foundations	291	"	3						
2. Clearance	92	11	9						
3. Main Masonry	44.696	6	10						
4. Ramming	26	5	11						
5. Step Masonry	17.181	4	3						
6. Dressing Centres	284	2	5						
7. Main Arch Masonry	7.703	11	9						
8. Masonry of Lions	2.951	9	3						
9. Do Do	1.650	15	4						
10. Excavation preparatory to plastering	37	4	"						
11. Plastering	6.072	2	3						
12. Excavation	433	11	6						
13. Ditto	870	"	3						
14. Spreading	321	4	"						
15. Excavation	45	2	1						
16. Ditto	7	9	8						
17. Spreading	19	"	"						
18. Filling Vaults	312	6	"						
19. Plain and Rora Masonry	19.584	8	4	102.581	3	10			
By Paid to Well Sinkers employed on well for mason houses				7	"	"			
" " Present to drivers on Rookee Banks extra work				25	"	"			
" " Contractor for Carriage of Bricks from upper to lower end of Aqueduct				500	"	"			
" " Contractor for Building Masons & Bildars houses				2.081	5	10			
" Purchase of Country Spurs & Cutt				2	"	"	105.196	9	8
Balance in hand							9.803	6	4
Total Costs							115.000	"	"

18 [illegible]

Head Clerk

79-80

Appendix Y.

27

Monthly Abstract Book.

Office Abstract of Overseer ——'d Accounts for the
28th of February 1853

Description of Work	Labor			Materials			Total		
Excavation 15th Mile	1446	9	8	369	9	9	1816	3	5
Do 16th Do	1474	13	10	492	13	2	1967	11	"
Do Do	668	2	"	51	10	6	719	12	6
Spreading the above	1117	8	8	"	"	"	1117	8	8
Excavation Roorkee Banks	538	6	4	"	"	"	538	6	4
Spreading the above	190	12	5	"	"	"	190	12	5
Removing Sand from Aqueduct	40	10	4	"	"	"	40	10	4
Spreading	269	"	"	"	"	"	269	"	"
Puddling	904	6	4	"	"	"	904	6	4
Totals on Original Works	6650	5	7	914	1	5	7564	7	0
Brick Kiln at Mukeenur	10	9	4	9	6	8	20	"	"
Do at Roorkee	28	15	8	21	"	4	50	"	"
Lime Kiln at Myapoor	5	"	"	5	"	"	10	"	"
Totals on Stores	43	7	"	35	7	"	80	"	"
Regular Establishment	"	"	"	"	"	"	10	"	"
Repairing Banks	18	15	4	1	"	8	20	"	"
Do Iron Work of Gates	"	8	"	4	8	"	5	"	"
Repairing Rutlee a Choki	5	"	"	32	4	10	37	4	10
Plantations	9	"	"	1	"	"	10	"	"
Purchase of Country Paper	"	"	"	"	"	"	1	"	"
Totals on Current Expenses	33	7	4	38	13	6	83	4	10
Fluctuating Establishment	"	"	"	"	"	"	144	11	1
Total on Sundries	"	"	"	"	"	"	144	11	1
Total expenditure during the Month	6728	5	11	988	5	11	7872	6	11

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Office Abstract of Overseer ——'s Accounts for month of March. 1853.

No.	Work.	Descriptions.	Labor			Materials			Total
B	6	Synabas Bridge	18	8	6	295	12	4	314
C	4	Excavation. 15th Mile	8038	10	8	2154	3	2	10,192
"	"	Do 16th Do	2805	3	10	601	13	3	3,407
"	"	Spreading the Above	3842	"	3	"	"	"	3,842
"	"	Excavation 16th Mile	42	2	"	"	"	"	42
"	"	Do 19th Do	37	11	"	"	"	"	37
"	"	Do Rookee Banks	802	4	5	"	"	"	802
"	"	Spreading last 2 Items	477	10	8	"	"	"	477
"	"	Removing Earth already deposited	212	"	"	"	"	"	212
"	"	Spreading	151	"	4	"	"	"	151
"	"	Ramming	221	13	11	"	"	"	221
"	"	Dressing Slopes	100	"	"	"	4	"	104
		Totals on Original Work	16749	1	7	3,051	12	9	19,801
M	2	Mulcewun Brick Kiln	1	15	8	48	"	4	65
"	3	Rookee Lime do	1	3	"	23	13	"	27
"	4	Charcoal Kiln at Rookee	1	3	"	23	13	"	27
"	"	Do at Mullikpoor	"	12	8	19	3	4	35
"	5	Making Sookee	20	"	"	112	8	"	132
		Totals on Stores	25	2	4	227	5	8	287
R	1	Regular Establishment	"	"	"	"	"	"	"
"	2	Repairs of Banks	"	"	"	"	"	"	"
"	3	Plantations	1	15	8	28	"	4	45
"	4	Purchase of Country Paper	"	"	"	"	"	"	"
		Totals on Current Expenses	1	15	8	28	"	4	45
S.		Fluctuating Establishment	"	"	"	"	"	"	"
		Totals on Sundries	"	"	"	"	"	"	"
		Total expenditure during the Month	10,776	3	7	3,307	2	9	20,083

M, 81; V. iii.

Office Abstract of L^d Superintendent ——'s accounts for the Month of April 1853.

29

Description of Work.	Labor			Materials			Totals.		
Excavation for foundations	291	"	3	"	"	"	291	"	3
Clearance	92	11	9	"	"	"	92	11	9
Main Masonry	5399	14	9	39296	8	1	44696	6	10
Ramming &c^a	26	5	11	"	"	"	26	5	11
Step Masonry	2778	15	3	14402	5	"	17181	4	3
L^d Resting Centres	284	2	5	"	"	"	284	2	5
Main Arch Masonry	1230	4	11	6473	6	10	7703	11	9
Masonry of Lions	350	"	"	2601	9	3	2951	9	3
L^d Do L^d o	603	14	10	1047	"	6	1650	15	4
Excavation Preparatory to plastering	37	4	"	"	"	"	37	4	"
Plastering	4210	7	9	1861	10	6	6072	2	3
Excavation 15th Mile	433	11	6	"	"	"	433	11	6
L^d Do 16th L^d Do	870	"	3	"	"	"	870	"	3
Spreading the above	321	4	"	"	"	"	321	4	"
Excavation 19th Mile	45	2	1	"	"	"	45	2	1
L^d Do Rowtee Banks	7	9	8	"	"	"	7	9	8
Spreading the above	19	"	"	"	"	"	19	"	"
Filling Vaults	312	6	"	"	"	"	312	6	"
Plain and Rowa Masonry	2503	"	"	17081	8	4	19584	8	4
Totals on Original Works	19817	3	4	82764	"	6	102581	3	10
Carriage of Bricks	"	"	"	"	"	"	500	"	"
Total on Stores							500	"	"
Purchase of County Pews & Desk	"	"	"	"	"	"	2	"	"
Total on Current Expenses							2	"	"
Paid Well Sinkers at Aqueduct Well	"	"	"	"	"	"	7	"	"
Presents to Drivers on Rowtee digging	"	"	"	"	"	"	25	"	"
Cost of Work people Houses	"	"	"	"	"	"	2081	5	10
Total on Sundries	"	"	"	"	"	"	2113	5	10
Total Expenditure during the month							105196	9	8

48½
27
20½

20½ 7 7 7

82

20

Appendix C.

Office General Accountscurrent with the Honble Coy:

The Northern Division Ganges Canal

L.Q.R. for the Month of February. 1853

Date	Receipts	Amount	
February 1	To Balance of last account		11,00
"	To Amount of Assignment (No. 10 of 1852/53 dated the 15th Ultimo) drawn by the Accountant N.W.P. on the Saharunpoor Treasury		75,0

Account Current with the Honorable Company

Cr.

Expenditure	Amounts			Total.		
By Original Works: Vizt:				31		
Expended on the Solani Earthen Aqueduct	7564	7	"	7564	7	"
By Current Expenses: Vizt:						
Plantations	10	"	"			
Ordinary Repairs: Repairing Banks 20.0.0						
Do Kulseea Choki 37.4.10						
Iron work & Gates 5.0.0	62	4	10			
Regular Establishment	10	"	"			
Office Contingent Expenses	1	"	"	83	4	10
By Sundries Account.						
Fluctuating Establishment				1244	11	1
By Mr. Finn: Advances				60,000	"	"
By Materials Accounts: Vizt:						
1 Advanced to Timber Contractors	7000	"	"			
2 Muhewun Brick Kiln	20	"	"			
2 Roorkee Do	50	"	"			
3 Myapoor Lime Do	10	"	"	7080	"	"
				74.872	6	11
Balance in hand				11.127	9	1
Total Cost Rs				86.000	"	"

82

82

The Northern Division Gang.

Dr: pany for the Month of March. 1853.

Date.		Receipts.	Amounts.				
March	1	To Balance of last Account					1
	9	To Amount of Assignment (No. 62 of 1852/53 dated The 25th ultimo) drawn by the Accountant M.P. on the Shahrampore Treasury	75.	00	..	..	75

… in account Current with the Honorable Com=

33 Cr:

Expenditure.	Amounts			Total		
By Original Works: Viz:						
Expended on Solani Earthen Aqueduct (Office)	1	"	"			
Expended on the Solani Earthen Aqueduct (Overseer)	19486	9	6			
Do on the Synebas Bridge	314	4	10	19801	14	4
By Current Expenses: Viz:						
Regular Establishment	10	"	"			
Ordinary Repairs: Repairs of Banks	600	"	"			
Plantations	30	"	"			
Purchase of Country Paper	2	"	"	642	"	"
By Sundries Account: Fluctuating Establishment	144	"	"			
Ballast Aqueduct for Workpeople &c	291	4	5	435	4	5
By Mr. Finn: Advances				40.000	"	"
By Materials Account: Viz:						
Nuhewun Brick Kiln	50	"	"			
Roorkee Lime Kiln	25	"	"			
Charcoal Kiln at Roorkee	25	"	"			
Do Do at Mullikpoor	20	"	"			
Roorkee	132	8	"			
Iron and Miscellaneous Metals	25.000	"	"	25.252	8	"
				86.131	10	9
Balance in hand				7868	5	3
Total — Rs				94.000	"	"

P 4

34

The Northern Division Ganges Co

Dr: pany for the month of April 1853.

Date		Receipts.	Amounts.			To
April	1	To Balance of last account				12707
	5	To Amount of Assignment (No. 15 of 1852/53 dated the 23rd ultimo) drawn by the Accountant N.W.P. on the Sukharun=pore Treasury	75,000	"	"	
		To M/s. Firm: Amt. Value of Undermentioned Materials delivered to Dy Superintendent.				
		50 Lakhs of Bricks @1000/. ——	50,000	"	0	0
		1,00,000 Mds of Stone Lime @20/. ——	20,000	"	0	0
		1,25,000 Do Sookee @ 12/. ——	15,000	"	0	0
			85,000	"	"	1,60,000
		Total Co.s Rs				1,72,707

account Current with The Honorable Com=
er:

Expenditure.	Amounts.			Total.		
By Original Works: Viz:				35		
Expended on Solani Earthen Aqueduct (By Supt.)	1.02.581	3	10			
Do Do (Office)	419	10	2	1.03.000	14	"
By Current Expenses: Viz:						
Regular Establishment	41	"	"			
Office Contingent Expenses	2	"	"	43	"	"
By Sundries: Viz:						
Well Sinkers at Masons &c a Well at Aqueduct	7	"	"			
Presents to Divers on Rookee Banks digging	25	"	"			
Cost (Contract) of Houses for Workpeople	2081	5	10			
Fluctuating Establishment	180	"	"	2.293	5	10
By Wm. Finn: Advances				40.000	"	"
By Materials Account: Carriage of Bricks				500	"	"
				145.837	3	10
Balance in hand				26.870	7	9
Total Costs				1.72.707	11	7

28/14/42/43

Appendix. D.

Half Yearly Sayer Account Current.

85

36

Sayer Account Current of the Roorkee Division

Dr. Year ending the 30th April 1853.

To Balance: Vizt:			
Cash	19,300	"	"
Inefficient	1255,000		12,74,300
To Civil Building Remittances: Vizt:			
To Amt of Assignment (No. 10 of 1852/53 dated 15th January 1853) drawn by the Accountant N.W.P. on the Sukharunpore Treasury	75,000	"	"
To Do (No. 12 do do dated 25th February 1853) drawn by Do Do Do	75,000	"	"
To Do (No. 15 do do dated 23rd March 1853) drawn by Do Do Do	75,000	"	" 225,00
Grand Total Cost Rs			14,99,300

14

7 7

15½

Roorkee.
1st May. 1853.

Division Ganges Canal Works for the Half
Yr:

37

By Ganges Canal: Viz:

(N: 220 Book of 1852/53 Military Boards Office) for Amt expended on the Solani
Masonry Aqueduct during the Quarter
ding 31st January 1853 Passed by the
Military Board on the 1st April 1853 ——— 1,00,000 " "
(N: 221 same Book and Office) for Ditto
the Solani Earthen Aqueduct Passed
do do do 1st February 1853 ——— 1,00,000 2,00,000 " "

By Balance: Viz:

Cash ——— 24,518 3 8

Inefficient: Viz:

of Bills Submitted to the Military Board
Audit as per last Account ——— 2,00,000 " "
Add since Submitted
25 for Solani Earthen Aqueduct ——— 136249 6 4
25 " Synalas Bridge ——— 314 4 10
2 " Establishment for February 1853 ——— 10 " "
3 " Do for March do ——— 10 " "
4 " Do for April do ——— 41 " "
5 " Ordinary Repair for February 1853 ——— 62 4 10
6 " Do Do for March do ——— 600 " "
7 " Plantations for February 1853 ——— 10 " "
8 " Do March do ——— 30 " "
9 " Office Contingent expenses for February 1853 ——— 1 " "
10 " Do Do for March do ——— 2 " "
11 " Do Do " April do ——— 2 " "
3,37,332 " "
educt Bills passed as above ——— 2,00,000 " " 137332 " "

nces on account of Original Works ——— 5,00,000 " "
on account of Stores ——— 4,30772 14 10
on account of Tools ——— 46676 13 6
to Wm Finn ——— 155000 " " 1132449 12 4

of Magazine Stores on hand ——— 5000 " " 1299300 " "

Grand Total ~~cost~~ ——— 14,99,300 " "

(Signed) Alg Goodwyn Captain.
Superintendent Wn Dn Ganges Canals.

86-87-88-89

Appendix. E.

Original Works Account Book.

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C4 Dr: Solani Earthen Aqueduct. Cr:

Date.	Description	Amounts	Total.	Description	
1853.					
Feby:	To Overseer		7,564 7 "	By Bill. No. 15 for 9 hs Quarter ending 30th April 1853	136
March	To Overseer	19486 9 6			
	" Cash	1 " "	19487 9 6		
April	To Dy Superintendent	102581 3 10			
	" Cash	419 10 2			
	" Sundries account	2873 5 4			
	" Tools account	3323 2 6	109197 5 10		
	Total Cost Co		136249 6 4	Total Credits	136

Detailed explanation of Debits

Date	Description	Labor			Materials			Totals		
	Excavation: 15th Mile: Wagon drawn by Hor:									
	5,00,966 C.Ft Ex; average distance 8,540 feet	1,446	9	8	369	9	9	1,816	3	5
	Excavation 16th Mile; Wagons drawn by horses,									
	3,99,300 C.Feet: Average distance 11,555 Feet	1,471	13	10	492	13	2	1,967	11	"
	Excavation 16th Mile; Wagons propelled by men;									
	2,02,112 C.Feet: Average distance 7,000 feet	668	2	"	37	10	6	719	12	6
	11,02,378 C.Feet in above three items spread	1,117	8	8	"	"	"	1,117	8	8
	Excavation Rookee Banks; Wagons propelled by									
	1,94,525 C.Feet men; av: distance 5,000 feet	538	6	4	"	"	"	538	6	4
	Spreading the Foregoing	190	12	5	"	"	"	190	12	5
	Removing 16,250 C.Feet of surplus Land from top of									
	Aqueduct & depositing it in Channel	40	10	4	"	"	"	40	10	4
	Spreading 1,30,000 C.Feet of earth already deposited	269	"	"	"	"	"	269	"	"
	Puddling 2,90,828 Do Do Do	904	6	4	"	"	"	904	6	4
	Totals	6,650	5	7	914	1	5	7,564	7	"
	Excavation 15th Mile; Wagons drawn by horses									
	21,30,206 C.Feet Average distance 10,760 feet	8,038	10	8	2,154	3	2	10,192	13	10
	Excavation 16th Mile, Wagon drawn by horses;									
	7,55,758 C.Feet Average distance 10,775 Feet	2,805	3	10	601	13	3	3,407	1	1
	28,85,964 C.Feet in above two Items Spread	3,842	"	3	"	"	"	3,842	"	3
	Excavation (Virgin Soil) 16th Mile: Baskets - av: distance									
	1,250 C.Feet 150 feet, up an slope of 50 feet & Spread	42	2	"	"	"	"	42	2	"
	Excavation 19th Mile; Wagons propelled by men;									
	12,175 C.Feet Average distance 5,000 feet	37	11	"	"	"	"	37	11	"
	Excavation Rookee Banks - as above - dist: 1,720 feet	803	4	5	"	"	"	803	4	5
	3,01,269 C.Feet in above 2 Items Spread	477	10	8	"	"	"	477	10	8
	1,07,875 Do Earth formerly deposited in Channel									
	removed to Embankments and spread	212	"	"	"	"	"	212	"	"
	50,340 C.Feet of Earth Spread a dist: of 200 feet	151	"	4	"	"	"	151	"	4
	Ramming earth round quadrantal & other Slopes	221	13	11	"	"	"	221	13	11
	Dressing Slopes 17,807 C.Feet of Excavation prepara-									
	tory to Dressing & 22800 Sq feet of Slopes dressed	100	"	"	"	"	"	100	"	"
	Totals	16,731	9	1	2,756	"	5	19,487	9	6
	Breaking up Revetment for foundation of Lions and									
	34,224 C.Feet of Excavation in foundations of Lions									
	and embankment Steps	291	"	3	"	"	"	291	"	3
	Clearing away argillaceous deposit from Revetmts	92	11	9	"	"	"	92	11	9
	2,91,372 C.Feet Plain Masonry in Revetments	5,399	14	9	39,296	8	1	44,696	6	10
	Parapets of Rookee Cattle Ghats commenced and ram-									
	ming earth below esplanade of Cattle Ghats	26	5	11	"	"	"	26	5	11
	108,342 C.Feet Step Masonry in Revetments	2,778	15	3	14,402	5	"	17,181	4	3
	Dressing earthen Cutters for Main Arches	284	2	5	"	"	"	284	2	5
	48242 C.Feet Arch Masonry	1,230	4	11	6,473	6	10	7,703	11	9
	Carried forward	10,103	7	3	60,172	3	11	70,275	11	2

C4. Dr: Solani Earthen Aqueduct. Cr.

Date	Description.	Amts:	Date	Description.	Amts:

B.6. Dr: Sysnabas Bridge. Cr.

Date	Description.	Amts:	Date	Description.	Amts:
1853					
March	To Overseer ———	312 4 10		By Bill No. 25 for the Quarter ending 30th April 1853 ———	3

Detailed Explanation of Debits.

Description.	Labor			Materials			Totals.		
Brought over	10,103	7	3	60,172	3	11	70,275	11	2
19,734 Cs feet Plain Masonry in Foundations and Pedestals of Lions	350	"	"	2,601	9	3	2,951	9	3
Bodies of Lions in Pourgren	603	14	10	1,047	"	6	1,650	15	4
Excavation below Canal bed Preparatory to plastering and refilling the Same	37	4	"	"	"	"	37	4	"
156,203 Sq feet Sq feet Plaster (38,032 feet not Polished)	4,210	7	9	1,861	10	6	6,072	2	3
Excavation 15th Mile; Wagons drawn by horses; 124,668 Cs feet Average distance 8840 feet	433	11	6	156	7	1	590	2	7
Excavation 16th Mile Wagons as before; 226,213 Cs feet distance 9,650 feet	870	"	3	263	3	1	1,133	3	4
350,883 Cs feet in last 2 Items Spread	321	4	"	"	"	"	321	4	"
Excavation 19th Mile; Wagons propelled by 10,800 Cs feet Steam; Av: distance 5,000 feet	45	2	1	"	"	"	45	2	1
Excavation Rockfill Banks; Same as before 1822 Cs feet Same distance	7	9	8	"	"	"	7	9	8
12,622 Cs feet in last 2 Items Spread	19	"	"	"	"	"	19	"	"
66,356 Cs feet Filled into Vaults & Rammed	312	6	"	"	"	"	312	6	"
1,27,008 Do Plain & Rora Masonry	2,503	"	"	17,081	8	4	19,584	8	4
Totals	19,817	3	4	83,183	10	8	1,03,000	14	0
Share of Sundries, divisible on Quarter Work							2,873	5	4
Do Work Do Do							3,323	2	6
3,000 Cs feet Masonry in Foundations and Wing Walls of Lyncbar Briage	18	8	6	295	12	4	314	4	10

Appendix F.

Store Account Book

L/Nr: M 1 — Timber

1853	To Balance				1,00,000
February	To Advances to Contractors				7,000
	Total Costs Rs				1,07,000

L/Nr: M 2 — Bric

1853	To Balance				1,00,000
February	To Mutcowa Kiln	20	"	"	
	" Roorkee do	50	"	"	70
March	To Mutcowa Kiln				50
April	To Carriage	500	"	"	
	" 50 Lakhs 2½ inch pukka @ 1000/-	50,000	"	"	50,500
	Total Costs Rs				1,50,620

L/Nr: M 3 — Lim

1853.	To Balance				50,000
February	To Myapoor Lime Kiln				10
March	To Roorkee Ditto				20
April	To 1 Lakh of Mds of Stone Lime @ 20/-				20,000
	Total Costs Rs				70,030

L/Nr: M 4 — Char

1853	To Balance				1,000
March	To Roorkee Kiln	25	"	"	
	" Mullikpoor	20	"	"	45
	Total Costs Rs				1045

L/Nr: M 5 — Stor

1853	To Balance				50,000
March	To 1104 Mands Roorkee @ 12/-				132
April	To 125,000 do do do				15,000
	Total Costs Rs				65,132

L/Nr: M 6 — Iron

1853	To Balance				9000
March	To 2000 Mds of Bar Iron @ 8/-	16,000	"	"	
	" 1000 " " Angle do " 9/-	9,000	"	"	25,000
	Total Costs Rs				34,000

ccount

42 Cr:

ary	By Lime Account			5	"	"
	" Brick do			1	"	4	6 " 4
h	By Charcoal account						42 14 "
	By Solani Aqueduct Revetments						360 " "
	By Balance						106,591 1 8
	Total cost Rs						107,000 " "

ccount

b b2 Cr:

ary	By Ordinary Repairs Account						5 " "
h	By Synabas Bridge			202	8	"	
	" Sonkee Account			112	8	"	315 " "
e	By Solani Aqueduct Revetments						51,500 " "
	By Balance						98,900 " "
	Total cost Rs						150,620 " "

ccount.

Cr:

ary	By Ordinary Repairs Account						22 8 "
ch	By Synabas Bridge						51 " "
e	By Solani Aqueduct Revetments						11,936 " "
	By Balance						58,025 8 "
	Total cost Rs						70,035 " "

ount.

Cr:

	By Balance						1,045 " "
	Total cost Rs						1,045 " "

ccount

Cr:

ary	By Ordinary Repairs			4	12	10	
h	" Synabas Bridge			40	12	10	
il	" Solani Aqueduct Revetments			18,652	4	8	18,697 14 4
	By Balance						46,434 9 8
	Total cost Rs						65,132 8 "

ccount

Cr:

ary	By Ordinary Repairs account						4 8 "
	By Balance						33,995 8 "
	Total cost Rs						34,000 " "

Ldr: **M 7** Live Sto

1853	To Balance		50,000
		Total Cost $	50,000

Ldr: **M 8** Miscellane

1853	To Balance		40,000
		Total Cost $	40,000

ccount A.

Cr:

uary	By Solani Earthen Aqueduct		772	13	2		
ch	" Do Do		2600	"	"	3,372	13 2
	By Balance					46,627	2 10
	Total Cost Rs					50,000	" "

ccount.

Cr:

uary	By Solani Earthen Aqueduct		141	4	3		
	" Plantations Account		1	"	"		
	" Brick Do		29	6	8		
	" Ordinary Repair Do		1	"	8	172	11 7
h	By Synabar Bridge		157	7	11		
	" Charcoal Account		"	2	4		
	" Lime Do		23	13	"		
	" Brick Do		48	"	4		
	" Plantations Do		28	"	4	257	7 11
b	By Solani Earthen Aqueduct & Revetments					315	11 10
	By Balance					39,254	" 8
	Total Cost Rs					40,000	" "

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Appendix. G.

Miscellaneous Accounts Book.

Ldr: N 1. — Regula

1853 February	To Overseer — ½ Bill for Establishment	10	"	"	
March	To Overseer — ½ Do Do	10	"	"	
April	To Dy Sup't — ½ Do Do	11	"	"	61

5 — 20 — 6

Ldr: N 2. — Ordina

1853 February	To One Mile of Embankment Repaired	20	"	"	
	" Repairs of Regulating Bridge Chains	5	"	"	
	" Do " Rubbish Shoots	37	4	10	62
March	To Contract Repairs of Banks - 20 Miles @ 3 £				600
	Total Cost Rs				662

Ldr: N 3. — Planta

1853 February	To planting 300 & clearing 1,000 Trees	10	"	"	
March	To 500 Teak trees & 1000 Young Plants - planted	30	"	"	40

Ldr: N 4. — Contin

1853 February	To 10 Quires Country Paper	1	"	"	
March	To 20 Quires Do	2	"	"	
April	To purchase of Country Pens and Ink	2			5

Ldr: F. — Mr Fin

1853.	To Balance				100,000
February	To Advances	60,000	"	"	
March.	" Do	40,000	"	"	
April.	" Do	40,000	"	"	140,000
	Total Cost Rs				240,000

Ldr: T. — Jov

1853	To Balance				50,000
	Total Cost Rs				50,000

Ldr: S. — Sumn

1853 February	To Fluctuating Establishment				14
March	To Do Do	144	"	"	
	" Well at Aqueduct for Work people	291	4	5	43
April	To Fluctuating Establishment	180	"	"	
	" Cost (Contract) of Work people Horses at Aqueduct	211 ⅓	5	10	29
	Total Cost Rs				287

Establishment

45 Cr.

3							
ary	By Current Bill No 2 of 1853 for Establishment	10	"	"			
eb	By Do Do No 3 do do do	10	"	"			
il	By Do Do No 4 do do do	41	"	"	61	"	"

Repairs

20 6 1/2 Cr:

53							
nuary	By Current Bill No 5 of 1853 for Ordinary Repairs	62	4	10			
ch	" Do Do No 6 Do Do Do	600	"	"	662	4	10
	Total Cost Rs				662	4	10

Account

Cr:

53							
ary	Bill No 7 of 1853 for Plantations	10	"	"			
ch	Bill No 8 Do Do Do	30	"	"	40	"	"

Contingencies

Cr:

53							
ary	By Bill No 9 for 1853 for Office Contingent Expenses	1	"	"			
ch	By Bill No 10 do do do	2	"	"			
e	By Bill No 11 do do do	2	"	"	5	"	"

Account

Cr:

53							
e.	By 50 Lakhs 2½" pukka Bricks @ 1000/-	50,000	"	"			
	" 1,00,000 Maunds Stone Lime @ 2/-	20,000	"	"			
	" 1,25,000 Do Soorkee @ 12/-	15,000	"	"	85,000	"	"
	By Balance				1,55,000	"	"
	Total Cost Rs				240,000	"	"

Account.

Cr:

53				
e.	By Solani Earthen Aqueduct	3,323	2	6
	By Balance	46,676	13	6
	Total Cost Rs	50,000	"	"

Account

Cr:

53				
e.	By Solani Earthen Aqueduct	2,873	5	4
	Total Cost Rs	2873	5	4

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(94)

Appendix. H.

Check Book

Dr: Accountant

1853 February	To Bills	100,000	"	"	
April	To Bills	100,000	"	"	200,000
	To Balance				1299300
	Total Cost £				1499300

Dr: Bu

1853 February	To Balance				200000
Do	To Current Expenses	83	4	10	83
March	To Current Expenses	642	"	"	642
April	To Current Expenses	43	"	"	
	" Original Works	136563	11	2	136602
	Total Cost £				337337

Dr: Cash

1853	To Balance				10,000
February	To Accountant M^r^	75,000	"	"	
March	" Do Do	75,000	"	"	
April	" Do Do	75,000	"	"	225000
	Total Cost £				235000

Dr: Curr

1853 February	To Labor	33	7	4	
	" Stones	38	13	6	
	" Overseer	11	"	"	83
March	To Labor	1	15	8	
	" Stnes	28	"	14	
	" Overseer	612	"	"	642
April	To Cash Account	41	"	"	
	" Dy Superintendent	2	"	"	43
	Total Cost £				768

W. P. 47 Cr:

By Balance				12,74,300	"	"
By Cash	75,000	"	"			
" "	75,000	"	"			
" "	75,000	"	"	2,25,000	"	"
Total Cost Rs				14,99,300	"	"

ount. Cr:

By Accountant MWP	1,00,000	"	"			
By Accountant MWP	1,00,000	"	"	2,00,000	"	"
By Balance				1,37,332	"	"
Total Cost Rs				3,37,332	"	"

ount A Cr:

By Overseer	9,000	"	"			
" Mr. Finn	60,000	"	"			
" Stores	7,000	"	"	76,000	"	"
By Labor	1	"	"			
" Mr. Finn	40,000	"	"			
" Overseer	15,000	"	"			
" Sundries	291	4	5			
" Stores	25,000	"	"	80292	4	5
By Dy: Superintendent	21,000	"	"			
" Mr Finn	40,000	"	"			
" Sundries	180	"	"			
" Original Work	419	10	2			
" Current Expenses	41	"	"	61,640	10	2
By Balance				17,067	1	5
Total Cost Rs				2,35,000	"	"

en Ses

By Bills	83	4	10			
By Bills	642	"	"			
By Bills	43	"	"	768	4	10
Total Cost Rs				768	4	10

Dr. Overseer

Dr: To Day Superintendent

1853					
	To Balance				4,00
April	To Cash				21,00
		7			7
	Total Costs				25,00

Dr: To Fie

1853					
	To Balance				1,00
February	To Cash	60,000	"	"	
March	" Do	40,000	"	"	
April	" Do	40,000	"	"	1,40
	Total Costs				2,40

Dr: To Overseer

1853					
	To Balance				3,00
February	To Cash				9,00
	Total Costs				9,00

Dr: To Overseer

1853					
	To Balance				5,00
March	To Cash				15,00
	Total Costs				20,00

Dr: To Labo

1853					
February	To Overseer				6,7
March	To Overseer	16,776	3	7	16,7
	" Cash				
April	To Day Superintendent				19,8
	Total Costs				43,3

Dr: To Magazi

1853					
July	To Balance				5,00

count

Cr:

e	By Labour		19,817	3	4		
	" Sundries		2,113	5	10		
	" Fines		500	"	"		
	" Current Expenses		2	"	"	22,432	9 2
	By Balance					2,567	6 10
19	Total Costs	7				25,000	7½ " "

count

Cr:

5 e	By Fines					85,000	" "
	By Balances					155,000	" "
	Total Costs					2,40,000	" "

ccount

Cr:

3 ary	By Labor		6,728	5	11		
	" Current Expenses		11	"	"		
	" Sundries		144	11	1	6,884	1 "
	By Balance					2,415	15 "
	Total Costs					9,300	" "
3 ch	By Labor		16,776	3	7		
	" Current Expenses		612	"	"		
	" Sundries		144	"	"	17,532	3 7
	By Balance					2,467	12 5
	Total Costs					20,000	" "

count

Cr:

3 ary	By Original Works		6,650	5	7		
	" Current Expenses		33	7	4		
	" Fines		44	9	"	6,728	5 11
h	By Original Works		16,750	1	7		
	" Fines		25	2	4		
	" Current Expenses		1	15	8	16,777	3 7
2	By Original Works					19,817	3 4
	Total Costs					43,322	12 10

es

Cr:

	By Balance					5,000	" "

LDr: Origin

1853.					
	To Balance				5.00
February	To Labor	6.650	5	7	
	" Stores	914	1	5	7.56
March	To Labor	16.750	1	7	
	" Stores	3.051	12	9	19.80
April	To Cash	419	10	2	
	" Labor	19.817	3	4	
	" Stores	82.764	"	6	
	" Sundries account	2.873	5	4	
	" Tool Account	3.323	2	6	109.1
	Total Cost Rs				6.365

LDr: D. 47; V iii. Stor

1853					
	To Balance				4.000
February	To Cash	7.000	"	"	
	" Labor	44	9	"	
	" Store	35	7	"	79
March	To Cash	25.000	"	"	
	" Labor	25	2	4	
	" Stores	227	5	8	252
April	To 1/4 Superintendent	500	"	"	
	" Mr. Finn	85.000	"	"	85.50
	Total Cost Rs				5.78

LDr: Sund

1853					
February	To Overseer				144
March	To Overseer	144	"	"	
	" Cash	291	4	5	435
April	To 1/4 Superintendents	2.113	5	10	
	" Cash	180	"	"	2293
	Total Cost Rs				2.872

LDr: To

1853	To Balances				50.000
	Total Cost Rs				50.000

ks 49 Cr:

By Bills				136563	11	2
By Balance				500000	"	"
Total Cost Rs				636563	11	2

count Cr:

By Original Works	914	1	5			
" Current Expenses	38	13	6			
" Stores	35	7	"	988	5	11
By Original Works	3051	12	9			
" Current Expenses	28	"	4			
" Stores	227	5	8	3307	2	9
By Original Works				82764	"	6
By Balance				430772	14	10
Total Cost Rs				517832	8	"

count 47 Cr:

By Original Works				2873	5	14
Total Cost Rs				2873	5	14

count Cr:

By Original Works				3323	2	6
By Balance				46676	13	6
Total Cost Rs				50000	"	"

Dr. Balance Sheet

	"	"	Accountant M.S.	12,993
1,37,332	"	"	Bills Account	
17,067	1	5	Cash Account	
2,567	6	10	D.J. Superintendents Account	
2,415	15	"	W. Overseer 's Account	
2,467	12	5	W. Overseer 's Account	
1,55,000	"	"	W. James Finn's Account	
5,000	"	"	Magazine Stores Account	
4,30,772	12	10	Store Account	
5,00,000	"	"	Original Works	
46,676	13	6	Tool Account	
12,99,300	"	"	Totals	12,993

9

For the Quarter ending 30th April. 1853.

51

Northern Division Ganges Canal.

Bill — No. 15.

The Honorable Company ——————— Dr.

To the following expenditure incurred in the Construction of an Earthen Aqueduct with Masonry ments &c across the Solani Valley during the Quarter ing 30th April 1853; being part of the project of the ges Canal. Vide Colonel Cautley's Report of 1845. Pages 31 and Revised Estimate of 1850 Pages 64-67.

Roorkee. 1st May. 1853.

Description of Expenditure	Labor	Materials	Sundries	Tools	Totals.
	7	7	7	7	8
Excavation from 15th Miles; Wagons drawn by Horses	1,44,698	36,999	5,412	4,612 1	1,91,7 " 8
Do 16th Do. Do Do	1,47,413 10	49,213 2	5,715 "	5,010 3	2,07,643
Do Do pushed by men	6,682 "	5,110 6	732	1,821 10	74,526
Loading the above 3 Items	1,17,388	" " "	815 "	2,827	1,13,410 3
Excavation from Roorkee Banks; Wagons pushed by men	53,864	" " "	5,411	1,392	55,745
Loading the above	19,012 5	" " "	185	413 "	19,710
Mud land carried from Top of Aqueduct by and deposited in channels	4,010 4	" " "	" 5 3	1 " 5	42 " "
Loading earth already deposited	269 " "	" " "	2 2 5	6 12 5	277 14 10
Puddling Do Do	9,046 4	" " "	739	2,212 9	93,461 0
Excavation from 15th Miles; Wagons drawn by Horses	8,038 10 8	2,15,432	2,821 4 "	2,621 0 4	10,738 6 2
16th Do, Do Do	2,805 3 10	60,133	10,331	8,712 1	3,598 " 3
Loading the above 2 Items	3,842 " 3	" " "	3,139	961 3 4	3,970 1 4
Excavation in 16th Mile (virgin soil) Carried in baskets and spread	422 "	" " "	" 5 4	" 15 3	438 4
16th do Wagons pushed by men	371 "	" " "	" 5 4	1 1 "	38 13 7
Roorkee Banks, Do Do	8,034 5	" " "	715 11	2,046	8,318 10
Loading the above 2 Items	4,771 0 8	" " "	3 13 3	1,2 " 7	4,938 6
Mud formerly deposited in Channel removed to embankments	212 " "	" " "	1 11 2	5 5 6	219 " 8
Loading earth already deposited	151 " 4	" " "	1 3 4	3 12 10	156 " 6
Forming earth round steps	2,211 3 11	" " "	1 12 5	5 9 6	2,293 10
Puddling Slopes	100 " "	" " "	" 12 10	2 8 4	103 5 2
Excavation for foundations of Piers & embankment					
Breaking up Revetment for former	291 " 3	" " "	2 5 3	7 5 4	300 10 10
Remove of Argillaceous deposit on Revetment	92 11 9	" " "	" 12 "	2 5 5	95 13 2
Brick masonry	5,399 4 9	39,296 8 1	995 11 1	1,143 1 10	46,835 3 9
Forming earth below esplanades of Cattle Ghats	22 6 5	" " "	" 3 "	" 9 1	23 2 6
Brick masonry	2,778 15 3	14,402 5 "	383 4 "	439 9 "	18,004 11 3
Pointing for main arch work dressed	284 2 5	" " "	2 4 4	7 2 7	293 9 4
Main arch Brick masonry	1,230 4 11	64,736 10	172 3 3	196 14 4	8,072 13 4
Carried forward — Cost Rs	33,481 6 5	63,842 5 9	21,374 5	2,488 8 4	1,01,949 8 11 4

Bill No. 15 — Continued

Description of Work	Labor	Materials	Sundries	Profit	
Brought forward — Costs	33,481 1 5	63,842 5 9	2,137 4 5	2,488 8 4	1,01
Parapets of Roskeen cattle shed	3 15 6	" " "	" " 11	" 1 8	
Plain masonry in foundations & pedestals of Lions	350 " "	2,601 9 3	65 9 2	75 6 10	
Masonry of bodies of ditto	603 14 10	1,047 " 6	36 10 6	42 3 1	
Excavation below Canal bed for plastering, & refilling that excavation	37 4 "	" " "	" 4 9	" 15 1	
Plastering	4,210 7 9	1,861 10 6	135 15 6	155 11 3	
Excavation from 15th Mile, wagons drawn by Horses	433 11 6	156 7 1	17 14 "	12 11 3	
Do 16th Do. Do Do	870 " 3	263 3 1	35 15 "	29 3 7	
Spreading the above 2 items in vaults	321 4 "	" " "	29 "	8 1 6	
Excavation from 19th Mile, wagons pushed by men	45 2 1	" " "	" 6 2	1 2 2	
Do Do Roskeen Banks	7 9 8	" " "	" " 3	" 3 1	
Spreading the last two items	19 " "	" " "	" 2 5	" 7 8	
Earth taken from channel filled into Vaults and rammed	31 2 6	" " "	2 8 "	7 14 "	
Plain & Rena masonry in Bank Steps	2,503 " "	17,081 8 4	438 1 3	500 9 "	20
Grand Total — Costs	43,199 2 "	86,853 12 6	2,873 5 4	3,323 2 6	1,3

Averages covering the above Expenditure.

Channel

5,00,766	C.Feet	excavation from 15th Mile, filled into Ballast Wagons, propelled along railway by Horses on average distance of 8540 feet and emptied by side of rail @ Rs 3/13/2 per 100 C.Feet	1,917 " 8	
3,99,300	Do.	from 16th do filled do and propelled do do 11555 do do @ Rs 5/3/2 per do	2076 4 3	
2,02,112	Do	Do Do Do propelled along rail by men, do do 7000 feet do do @ Rs 3/11/0 per do	745 2 6	
11,02,378	Do.	in last 3 Items spread in channel @ Rs 1/1/9 per do- Giving aggregate rates as follows:- 15th Mile: Work by horses @ 4/13/11 per 100' 16th Do.: Do @ Rs 6/3/11 per Do. Do Do: Work by men @ Rs 4/11/9 per Do.	1154 10 3	
1,94,525	Do	Excavation from Roskeen Banks filled into Ballast Wagons, propelled along railway by men an average distance of 5,000 feet and emptied by side of rail @ Rs 2.13.10 per 100 C.Feet	557 4 5	
1,94,525	Do.	in last item spread in channel @ 1/0/3 per do	197 1 10	
		Giving an aggregate rate of Rs 3/14/1 per 100 C.Ft:		
16,250	C.Feet	of Surplus Sand removed from Top of Aqueduct arches and deposited in channel @ Rs 3/13/0 per 100 C.Feet	42 " "	
1,35,000	Do.	of Earth already deposited in channel & spread @ Rs 2/0/11 per do. N.B. This is, generally speaking Shallow digging, finishing off bed & sides	277 14 10	
		Carried forward — Costs	6,967 6 9	

	Brought forward — Cost Rs —		6.967	6	9			
928	C.ft of Earth already deposited in channel pro-vided @ Rs 3/3/5 per 100 C.ft		934	6	10	7.901	13	7
	Embankments							
206	C.ft Excavation from 15th Mile filled into bal-last Wagons propelled along railway by horses an average distance of 10760 feet and emptied by side of rail @ Rs 5/0/8 per 100 C.ft		10.738	6	2			
738	Do from 16th Do, Do Do Do 10775 feet and do do @ Rs 4/12/2 per 100 C.ft		3.598	"	3			
964	Do in last two items spread @ Rs 1/6/- per do		3.970	1	4			
	Giving aggregate rates as follow:							
	15th Mile, work by horses Rs 6/6/8 per 100 C.F.							
	16th Do, Do Do Do " 6/2/2 Do							
250	Do Do (virgin soil) carried in buckets a distance of 150 feet up a height of 25 feet and spread in embankments @ Rs 3/0/10 per 100 C.feet		43	8	4			
195	Do Do from 19th Do filled into ballast Wagons propelled along railway by men an average distance of 5000 feet and emptied by side of rail @ Rs 3/2/2 per 100 C.feet		38	15	7			
1074	Do Do from Rorkee Banks do do do 4720 feet and do do @ Rs 2/14/7 per 100 C.feet		831	8	10			
269	Do in last two items spread @ Rs 1/10/2 per do		493	8	6			
	Giving aggregate rates as follow:							
	19th Mile work by men Rs 4/13/4 per 100 C.ft							
	Rorkee Banks Do " 4/8/9 Do							
875	Do earth formerly deposited in channel removed to embankments and spread @ Rs 2/5/6 per 100 C.feet		219	"	8			
340	Do Do Do in embankments spread a distance of 200 feet @ Rs 3/9/7 per do		156	"	6			
	Cost of ramming earth round quadrantal & other Steps		229	3	10			
207	C.ft of Excavation preparatory to dressing Slopes @ Rs 3/- per 100 C.feet — 53.6." 9							
300	Sq.feet of Slopes dressed @ Rs 2/3/0 per 100 S.F. — 49." 14." 5		103	3	2	20,421	11	2
	Revetments.							
	Cost of breaking up revetment for foundations of Lions together with 34224 C.ft of Excava-tion for foundations of Lions and of em-bankment Steps		300	10	10			
	Clearance of argillaceous deposit on revetment		95	13	2			
372	C.ft of plain masonry in Revetments, mortar being equal portions of Lime, Rorkee and Sand @ 16/1/2 per 100 C.feet		46.835	3	9			
	Parapets of Rorkee Cattle Ghats commenced by the Price & Cost of ramming earth below esplanade of Cattle Ghats		27	4	7			
	Carried over — Cost Rs —		47259	"	4	28,323	8	9 4

Bill — No. 15 — Continued

		Brought forward Cost Rs	47259	.	4	2
108.342	C.ft	Ft of Step masonry in Revetments, mortar as before, @ Rs 16/9/10 per 100 C.ft	18004	11	3	
		Cost of dressing earthen Centering for main arch work	293	9	4	
48.242	C.ft	Arch Masonry & Revetment, mortar as before @ Rs 16/11/9 per 100 C.ft	8072	13	4	
19.734	Do	Do plain Masonry in foundations and pedestals of Lions mortar as before @ Rs 15/5/9 per do	3092	9	3	
		Masonry of bodies of Lions in progress	1729	12	11	
		Excavation below Canal bed for plastering, and re-filling the same — no measurements	38	7	10	
1.56.203	Sq.ft	Puttu plaster, 1.18.171 Sq.ft being completely finished and remainder being unpolished @ Rs 4/1/2 per per 100 Square feet	6363	13	..	
1.24.668	C.ft	Excavation from 15th Mile filled into ballast wagons propelled along railway by horses, an average distance of 8840 feet and emptied by side of rail @ Rs 4/15/8 per 100 C.ft	620	11	10	
2.26.215	Do	Do 16th Do, Do Do 9650 feet and do do @ Rs 5/4/9 per 100 C.ft	1198	5	11	
3.50.883	Do	in last two items spread in Revetment vaults and slightly rammed @ Rs 5/15/1 per do	331	14	6	
		Giving aggregate rates as follows:				
		15th Mile, work by Horses @ Rs 5/14/9 per 100 C.ft				
		16th Do, Do Do " " 6/3/10 " Do				
10.800	C.ft	Excavation from 19th Mile filled into Ballast Wagons, propelled along railway by men, an average distance of 5.000 feet and emptied by side of rail @ Rs 4/5/1 per 100 C.ft	46	10	5	
1822	Do	Do from Rowtee Banks Do Do Do 5.000 feet and do do @ Rs 4/4/7 per 100 C.ft	7	13	..	
12622	Do	in last two items spread in Vaults and rammed slightly @ Rs 1/8/11 per 100 C.ft	19	10	1	
		Giving aggregate rates as follows				
		19th Mile work by men @ Rs 5/14/- per 100 C.ft				
		Rowtee Banks Do Do " " 5/13/6 Do				
66356	C.ft	Earth formerly deposited in channel removed to Revetments vaults and rammed @ Rs 4/13/10 per 100 C.ft	322	12	..	
1.27.008	Do	Miscellaneous masonry (chiefly plain) in embankment Steps, mortar as before @ Rs 16/2/6 per 100 C.ft	20323	2	7	10
		Grand Total Cost Rs				13

Remarks on the Rates.

Last Quarters Rates.	Recent Quarter Rates.	
5/9/10 per 100 C.ft 9400 distance 1st August 1852	3/13/2 per 100 C.ft 8540 feet distance.	Earthwork in channel in ballast Wagons drawn by Horses appears this Quarter at about its natural rate. Last quarter, owing to the number of horses in training and consequently not effective for work, the rate was very high. But if comparison is made with the rate of the quarter ending 31st July, due allowance for distance being afforded at 8as per 100 feet which is perhaps fair, the present rate
5/2/- per 100 C.ft 11540 ft distance		

Carried forward Cost Rs 13

Rate per Quarter		£	s	d
	Brought Forward ——— Cost B ———	1,362	9	6
5/3½ per 100 C.ft at 1555 feet distance.	brought forward will be shewn to be correct enough. This will appear better by comparison of the 16th Mile rate as per margin. The two rates are here shewn to be almost identical.			
3/11 per 100 C.feet 1000 feet distance	Same work in ballast Wagons propelled by men 16th Mile.			
1/.19 per 100 C.ft.	Spreading Earth in Channel. This rate in rate is due I believe to an expression of my opinion That the Spreaders under Mr Parker actually had some slight ground of complaint That too much work was exacted from them. Certain it is That they were leaving our works and I therefore without giving in to them immediately requested Mr Parker to relax his rate as early as he could consistently with the maintenance of discipline. Reference to old back rates and consideration of the fact That we are not in a position to be able to guard with our Workmen will I am sure bear me out in this.			
2/0.10 per 100 C.feet 5000 ft dist.ce	Earthwork in channel in Ballast Wagons propelled by men from Roorkee Bank, agrees very well with Same work from the 16th Mile, due regard being had to difference of distances.			
3/3½ per 100 C.ft	Puddling earth already deposited. Comparison of rates, here is little more than a form. Distances from which earth already deposited is moved, and facilities for watering that earth, vary so much in different localities That great varieties of rates must always exist.			
	It is not supposed necessary to notice rates of earthwork further.			
	carried over ——— Cost B ———	1,362	9	6

Rates Last Quarter	Rates Present Quarter.	
		Brought forward — Cost Rs — 1.36.2.4
1st August 1852 15/3/- per 100 C.ft	16/1/2 per 100 C.ft	Plain masonry cannot properly be compared with the plain and rubble masonry of last quarter the rate of which moreover was then presumed to be incorrect. If however the comparison is made with the plain masonry of Cattle Ghats for the Quarter ending 31st July 1852, and it is considered that a rise in the price of Bricks should affect the Cost of 100 C.ft of masonry to the extent of 1 Anna 5, the rates compared will agree within 3 pie of each other. Great part of this quarters masonry is in bricking out.
1st May 1852 15/3/2 per 100 C.ft	16/11/9 per 100 C.ft	Arch masonry under Steps is here compared with that in Cattle Ghats Than which after making allowance for rise in price of bricks, it is 10 Annas 2 per 100 C.ft dearer. The difference is due entirely to the different quantity of materials used, the rate of labor in the present instance being 1/6th lower than before.
1st May 52 15/10/3 per 100 C.ft	16/9/10 per 100 C.ft	Step masonry after due consideration of rise in the price of bricks is within one anna exactly of its proper rate. Last quarters rate is purposely rejected as incorrect.
	4/1/2 per 100 Sq.feet	Pukka plaster has been executed before on this work as per Bill of 1st May 1850 @ 5/0/9 per 100 Square feet; as per Bill of 1st February 1851 @ 5/0/5 per 100 do; and as per Bill dated 1st May 1851 at 4.. 15.. 4 per 100 do; but I am sorry that this rate does not afford ground for congratulation, as, in addition to the work not being all finished, it is not I confess as well done as before. This will be carefully looked to for the future.
		A Sets
		Carried forward — Cost Rs — 1.36.8.4

Bill — No. 15 Continued

Brought forward — Costs —				136249	6 4
Assets to Account.					
Cash received in part of the general assignments for the Ganges Canal Works —	136249	6	4		
Do expended being the amount of this Bill —	136249	6	4		
Grand Total — Costs — One Lakh, thirty six and two hundred and forty nine —				136249	0 0

The Secretary
Military Board
Fort William

(Signed) A.G. Goodwyn. Lieutenant.
Ex: Engr: No. 2 Ganges Canal Works.

I declare upon my honor that the sum
ed in this Bill has been duly expended for the
pose set forth.

(Signed) A.G. Goodwyn. Lieutenant.
Ex: Engr: No. 2 Ganges Canal Works.

Abstract.

Abstract by the Director of Works, showing the amo
expended and the quantity of work executed on the Solani Ca
Aqueduct up to the 30th April 1853

Work executed.		Expended
Earthwork of all Sorts	Masonry of all Sorts	
Cubic feet.	Cubic feet.	
460,95,937.242	43,41,875.062	up to 31st January 1853 ——— 8
		Captain Goodwyn's Bill No. 15 for the quarter
48.95.948.0	5.94.698.0	ending 30th April 1853 ——— 1
509.91.885.242	49.36.573.062	26
86 Cutoffs: 798 Piles driven. 27,610 Sq feet of Puttha Plaster. 547.79 Rft Undersinking Blocks. 2,29,402 Sq. feet Slopes dressed.		Total Costs ——— 9

Comparing the rates with those of the Revised Estimate we have

Earthwork as per Estimate

509,91,885 C.ft of Excavation of all Sorts @ 3/13/3 per 100 C.ft ——— 1
Add 5 per cent for Contingencies ———
Amount ——— 2

Earthwork as per Bill

509,91,885 C.ft of Earthwork of all Sorts @ 4 1/2 nearly per 100 C.ft ———
Showing an excess of Costs ———

Masonry as per Estimate

49,36,573 C.ft of masonry of all sorts @ 16/4/3 per 100 C.ft ———	8,02,964	7	2
Add 5 per Cent contingencies ———	40,148	3	7
Amount ———	8,43,112	10	9

Masonry as per Bill

49,36,573 C.ft of masonry of all Sorts @ 15/3/4 nearly per 100 C.ft ———	7,56,894	2	10

Showing a saving of Costs ——— 8

On the whole work executed up to the 30th of April 1853, there is therefore a saving of ——— Costs ——— 8

On the 30th of April 1853 the average rate of the Earthwork was increased by the sum of 3as/8 per 100 Cubic feet; and the rate is now 4 1/2 annas above that of the Estimate - but the rates of the period under review are

On masonry the average rate has also increased 2 annas per cent beyond that exhibited on the 31st January 1853, but there is still a consid margin when comparing it with the Estimate.

I beg to refer the Board to Captain Goodwyn's remarks, and comparison with former Quarters which meet with my approval to recommend that the Bill be Sanctioned.

Signed P.T. Cautley. Lt Col
Director Ganges Canal Wo

For the Quarter ending 30th April 1853.

Rr Lowr Ganges Canal.

Survey Report and Statement of Measurements of certain Work executed in the partial construction of an Earthen Aqueduct with Masonry Revetments across the Solani River during the Quater ending 30th April 1853.

Roorkee. 1st May. 1853.

Description.	Measurements.						Masonry.				Surkhee Plaster.
	L.	B.	D.	Area.	Nos.	Contents.	Plain.	Steps.	Arch.	Miscellaneous	
15	5	4	—	—	2	4	—	—	—	—	—
tment	270	3'.1"	3'	"	"	2.498					
	117	"	"	13.10	"	1.532					
	10	"	"	21.32	4	853					
	260	"	"	6.20	"	2.132					
	300	"	"	7.3	"	2190					
	1.465	"	"	4.36	"	6.387					
	1.725	"	"	13.10	"	22.598					
						38.190					
Deduct	5	"	"	13.10	15						
100	5	"	"	4.36	10	1.201	36.989				
	200	"	"	5.5	"	1.100					
	640	"	"	18.8	"	12.032					
	350	"	"	9.63	"	3.371					
	93	"	"	3.48	"	324		16827			
	250	"	"	10.3	"	2.575			2.575		
	375	3".1"	4'	"	"	4.625					
	9½	1".7"	4'	"	"	60					
	310	3".9"	1".9"	"	"	2.034					
	250	4".5"	3'	"	"	3.313					
	110	1".7"	2".9"	"	"	479					
	110	3".7"	1".9"	"	"	690					
	1.300	"	"	2.6	"	3.380					
	1.250	"	"	1	"	1.250					
	630	3".1"	6".9"	"	"	13.112					
	1.030	3".1"	11'	"	"	34.934					
	1.260	"	"	13.1	"	16.375					
	515	3".1"	6"	"	"	794					
	9½	1".7"	10'	"	5	752					
	10	3".1"	7".6"	"	2	463					
	10	3".1"	13'	"	3	1.202					
	10	"	"	7.06	3	212					
	735	"	"	8.2	"	6.027					
	430	"	"	8.2	"	3.526					
	10	3".1"	6".6"	"	"	170					
	10	"	"	9.6	"	96					
	1.400	"	"	3.86	"	5.404					
	10	3".1"	13'	"	"	401					
	10	"	"	7.06	"	71	99.370				
	1.300	"	"	23.93	"	31.109					
Previously reported						21.462		9.647			
	1.904	"	"	10.3	"	19.611					
						10.258			9.353		
	280	2'	2'	"	"	1.120					
	683	3".1"	5'	"	"	10.530					
	455	3".1"	6".6"	"	"	9.119					
	360	3".1"	6".9"	"	"	7.492					
Brought forward						28.261	136.359	26.474	11.928	"	"

Description	Measurements. L.	B.	D.	Area	No.	Contents	Masonry. Plain.	Steps.	Arch.	Miscellaneous
Brt forward						28,261	1.36,359	26.474	11.928	
	554	3'.1"	6'.0"	"	"	8.541				
	380	3'.1"	1'.0"	"	"	1,171	37.973			
Sig. P. 105.	270	"	"	8'	"	2.160				
	190	"	"	23.93	"	4.547		6.707		
	280	"	"	9	"	2,520				
	657	"	"	10.3	"	6.767			9.287	
	212	3'.1"	6'.8"	"	"	4.358				
	190	3'.1"	6'.8"	"	"	3.954				
	108	3'.1"	6'.0"	"	"	1.998				
	100	"		13.1	"	1.310				
	600	4'.3"	1'	"	"	2.550				
	5	"	"	16.6	6	498	14.668			
	270	"	"	11.11	"	3.000				
	100	"	"	21.18	"	2,118				
	200	"	"	23.93	"	4.786				
	400	"	"	18.	"	7.200		17.104		
	1.584	"	"	10.3	"	16.315				
Deduct previously reported						6.767			9.548	
	558	4'.3"	1'	"	"	2,391				
	1040	4'.3"	9"	"	"	3.315				
	535	"	"	2.94	"	1.573				
	1.250	"	"	1.94	"	2.425				
	25	"	"	16.69	"	415				
	180	"	"	21.32	"	3.838				
	500	"	"	8.22	"	4.110				
	50	3'.1	7'	"	"	1.079				
	350	"	"	13.10	"	4,585				
	600	"	"	2.6	"	1.560				
	600	"	"	7.06	"	4.236				
	855			21.32	"	18.229				
	9	1'.7"	2'.6"	"	"	35	47.771			
	400	"	"	5.93	"	2,372				
	1,412	"	"	23.93	"	33,789		36.161		
	900	"	"	10.5	"	9.270			9.270	
	1.370	"	"	2.54	"	3.480				
	568	"	"	13.10	"	7.441				
	788	"	"	2.6	"	2,049				
	944	"	"	2.94	"	2.775				
	400	3'.1"	9"	"	"	925				
	5	"	"	18.12	8	725				
	1170	"	"	7.06	"	8.260				
	863	"	"	21.32	"	18.399				
	651	"	"	13.1	"	8.528				
	498	"	"	2.94	"	1.464				
	10	3'.1"	6'	"	3	555	54,601			
	915	"	"	23.93	"	21,896		21,896		
	797	"	"	10.3	"	8,209			8.209	
Embankment Steps	46'.½	7'	15'.9"	"	"	5,085				
	23'.8"	2'.6"	2'	"	"	144				
	18'.10"	2'.6"	29'.6"	"	"	1.389				
	7'.4"	2'	2'	"	2	59				
	7'.2	2'	22'	"	"	323				
	4	7'	2'	"	"	56				
					18	7.056			1.27.006	
Pedestals of Lions	23	11'	10.6"	"	4	10,626				
	23	11'	9'	"	4	9.108	19.734			
Ogees & Revetments	315	6'.3"	"	1.369	"					
	8	9'.3"	"	74	"					
	646	3"	"	161	"					
	648	2½"	"	135	"					
	648	1'.11"	"	1242	"					
	628	3"	"	162	"					
	647	3"	"	162	"					
	646	3"	"	161	"					
	646	7½"	"	404	"					
	646	1'.2"	"	753	"					
				5223	3¾	19.586				
Carried over						19.586	3.11.106	1.08.342	48.242	1.27.006

Description.	Measurements. L.	B.	D	Area	No.	Contents.	Masonry. Plain	Steps	Arch	Miscellaneous	Rubble Plaster.
Light tower						19,586	3.11.106	1.08.342	48242	1.27.008	"
Revetments	350'	"	"		2	25.795					
	350'	"	"	"	"	2.450					
	512'	"	"	"	"	17.579					
	100'	"	"	"	"	667					
	4'	"	"	"	2	24					
	54'	"	"	"	"	486					
	area as above			5223	1/4	1,306					66,587
	350'	15.10"	"	"	"	5,542					
	320'	11'	"	"	"	3,520					
	320'	3.8"	"	"	"	1,173					
	10'	9.4"	"	"	2	187					
	170'	15.10"	"	"	"	2,692					
	170'	8"	"	"	"	114					
	320'	7'	"	"	"	2,240					
	104'	28.4"	"	"	"	2,946					
	100'	6.7"	"	"	"	658					
	104'	1.10"	"	"	"	572					
	104'	1.16	"	"	"	2,097					
	104'	8.2"	"	"	"	849					23.896
	835'	"	"	7.10	"	5.928					
	1261'	"	"	16.75'	"	21,122					
	957'	"	"	5.0	"	4.785					
	2274'	"	"	6.87	"	15.622					
	"	"	"	4565.75'	4	18.263					65.720
Grand Total Contents							3.11.106	1.08.342	48242	1.27.008	1.56.203

15 5 4 4 4 2 4 4 4 4 4

Excavation &c.

Measurements B.	D.	No.	Contents.	Earthwork Channel	Banks	Filling Vaults.	Remarks.
3'	2		4½	4	4	3½	
15'	"		15.000				
5.6"	"		20.790				
16.6	"		3.91.875				
			4,27,665	3,29,066	5,264	93,335	From 15th Mile in horsed Wagons. Distance 8500 feet.
17'	"		1.57.080				
7½	"		12,150				
1¾	"		5.166				
13'	"		45.630				
15'	"		9,180				
			2,29,206	52,400	1,76,806	"	From 16th mile by rail by mens, 6200' dist: and " do do in horsed Wagons 8500 ft distance.
16'	"		11,440				
11'	"		18,150				
7'	"		17,500				
			47,090				
			4990				
			42,100	20,400	21,700	"	From Ranks Banks by rail by mens. 5250' distance
23'	"		18,538				
9'	"		1,29,330				
14.6"	"		51,200				
26.6"	"		1,05,894				
14.6"	"		1,63,372				
5.6"	"		12,980				
			4,81,314	1,48,000	3,28,081	5,233	From 15th Mile in horsed Wagons: dist: 9,000 feet.
3.3"	"		6,187				
16'	"		94,080				
12.6"	"		26,250				
26'	"		11,700				
691	"		34,550	"	"	1,72,767	From 16th do do do.
Total Carried over				5,49,866	5,31,851	2,71,335	

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Measurements.					Earthwork.			
L.	B.	D	No.	Contents	Channel	Banks.	Filling Vaults.	Remarks.
Brought over					5.49.866	5.31.851	2.71.335	
61'	10'	8'	"	4.880				
111'	9'	8'	"	7.992				
70'	30'	2'.6"	"	5.250				
40'	10'	5'	"	2.000				
180'	12'	5'	"	10.800			10.800	From 19th Mile by rail by men. 5000 ft
				30.928	1.225	16,775	1,822	From Rookee Banks. do do.
375'	10'	14'	"	52.500				
845'	10'	9'	"	76.050				
940'	5'	13'.9"	"	64.625				
460'	16'	7'	"	51.520				
825'	10'	15'	"	1.23.750				
50'	Area	1239	"	61 950				
				4.30.395	23.900	3.80.395	26,100	From 15th Mile in horsed Wagons, 10
90'	18'	26'	"	42,120				
64'	27'	16'	"	27.648				
150'	43'	16'	"	1.03.200				
300'	55'	2'.6"	"	41,250				
				2.14.218	"	2.14.218		From 16th Do Do Do.
340'	30'	6'	"	61,200				
38'	31'	4'.3"	"	5.006				
155'	11'	11'.6"	"	19.608				
271'	12'	2'.6"	"	8.130				
27'	5'	3'	"	4.065		12.195		From 19th Mile by rail by men; 5000
				98.009	39.100	46.711	"	From Rookee Banks do do do.
287'	30'	16'	"	1.37.760				
654'	10'	14'	"	91,560				
440'	15'	16'	"	1.05.600				
324'	30'	2'	"	19.440				
700'	20'	4	"	56.000				
50'	Area	1857	"	92.550	"	5.02.910	"	From 15th Mile in horsed Wagons,
145'	28'	26'	"	1.05.560				
90'	10'	26'	"	23.400				
768'	48'	1'.9"	"	64,512				
231'	14'	16'	"	51,744				
50'	45'	11'	"	24,750				
167'	45'	5'.6"	"	41,332				
49'	49'	17'	"	40,817				
620'	6.6	5'.8"	"	22,837				
50'	12'	9'.6"	"	5.700				
50'	Area	179	"	8.950	70.900	2.56.090	"	From 16th Do do. do.
				3.89.602	62.612	"	"	Do Do by rail by men, 7200
253'	47'	2'	"	23,782				
106'	47'	1'.6"	"	7.473				
353'	47'	7'.3"	"	1.20.285				
106'	46'	7'	"	34.132				
144'	13'	5'.3	"	9.828				
				1.95.500	58.000	1.37.500	"	From Rookee Banks do do 4
555'	10'	3'	"	16.650				
205'	5'	15'.6"	"	15,887				
205'	9'	5'	"	9.225				
200'	20'	3'	"	12.000				
1212'	10'	16'.3"	"	1.97.556				
1212'	10'	4'.3"	"	52,116				
30'	15'	16'	"	7.200				
150'	56'	5'.6"	"	46,200				
17'	54'	9'.9"	"	8,957				
50'	Area	1357	"	67.850	"	4,33.635	"	From 15th Mile in horsed Wagons
30'	54'	9'.9"	"	15.795				
213'	50'	5'	"	53,250				
40'	10'	5'	"	2.000				
230'	50'	1'.9"	"	20,125				
1330'	50'	2'	"	133,000				
130'	10'	16'.6"	"	21,450				
130'	10'	2'	"	2,600				
50	Area	740	"	37.000	1.01.600	79.565	17,555	From 16th Do, Do Do., do do.
				2.85.220	86.500	"	"	Do Do by rail by men, 7200
252'	34'	2'	"	17,136				
252'	14'	8'	"	28,224				
250'	22'	8'	"	44,000				
100	30	6.815	"	20,625				
				1.09.985	54,500	55,485	"	From Rookee Banks do do, 5400
543'	10	2.3	"	1,09,957				
543'	3'	3.6	"	5.702				
477'	5'	21'	"	50.085				
477'	3'	5'	"	7.155				
200	16'	2	"	6.400				
657	11.9	17	"	1,11,261				
Carried over				2,90,560	10,48,203	26.67.333	3.27.612	

Earthwork

Lo	No:	Contents.	Channel	Banks	Filling Vaults	Spreading Earth already deposited	Trimming	Removing from Channel	Miscellaneous	Lowering Slopes.	Remarks.
———	———	290.560	104.8203	266.7333	32.7612	"	"	"	"	"	
30'	"	60.000									
1¼	"	7.041									
5¼	"	10.710									
6'	"	85.360									
7'	"	700									
30'	"	25.350		4.7921							From 15th Mile in horse wagons, 12000 ft.
15½	"	9.975									
15½	"	68.200									
5½	"	41.077									
9'	"	8.640									
2'	"	72.080									
1½	"	63.600									
8'	"	28.800	2.2680	2.9079	3.5893	"	"				From 16th do do do do do.
		29.2872	600	"	"						Do Do rail by mess. 9000 feet. dist.
7'	"	32.200	21.300	10.900							From Rookee Banks do do, 5800 do do.
3	"	45.000									
3'	"	26.400									
1'	"	6.600									
2	"	88256									
2'	"	500				"	"	60000			In Embankments.
		166756				80.000	"	"			In Channel.
2'	"	65.000				"	"	26756			In Vaults.
1½	"	7875				"	"	47.875			To Embankments.
		72.875				25000	"	"			In channel.
3'	"	"				30.000					In Do.
10'	2	14.400									
8'	2	3.600									
7'	"	32.340									
		50.340				50340					In embankments.
3'	"	"						16500			To Vaults.
2	6	"						8100			Do.
5'	"	"						15.000			Do.
4.30	"	30.933									
1'	"	21.600									
1'	"	236000				288533					In channel.
4½	"	"				2295					Do.
2½	2	6.750									
1'	"	7.500		14.250							From 16th Mile in baskets; dist 1350 ft.
13'	"	"						16.250			Sand removed from Top of Aqueduct.
7'	"	6.550									
3½	2	4.025									
7'	4	5.800									
4½	"	1.350						17807			Reparations to dredging Slopes.
"	"	"							22800		
1'	4	1.012									
11'	4	11.132									
10'	4	21.600									
6'	"	480						34224			For foundations of Lions and Embankment Steps.
Total		1296903	3201483	3633305	1853340	2908828	174231	68281	22800		Earthwork Exca.

(signed) A.G. Goodwyn. Lieutenant.
Ex: Engr: Wn Dn Ganges canal Works.

Abstract of the foregoing.

Description	Masonry. Plain.	Masonry. Steps	Masonry. Arch	Masonry. Rubble Rear	Masonry. Rubble Facing	15 ft. Miles Mortar.	Earthwork. By Rail. 16th Mile. Mortar.	Earthwork. By Rail. 16th Mile. Men.	Earthwork. By Rail. 19th Mile. Mortar.	Earthwork. By Rail. 19th Mile. Men.	Rock in Banks. Mortar.	Rock in Banks. Men.	15 ft. Miles in tail Race	Excavating Canal & already deposited.	Removing do. to Channel.	Puddling.	Removing Sand from Aqueduct.	Foundations.	Preparing & dressing Steps.	Dressing Copes.	Remarks.
	C. feet	C. feet	C. feet	C. feet	Sq. feet	C. feet	C. feet	C. feet	C. feet	C. feet	C. feet	C. feet	C. feet	C. feet	C. feet	C. feet	C. feet	C. feet	C. feet	C. feet	
Revetments	291372	108342	48242	"	*156203	124663	226215	"	10800	1822	"	"	"	66356	"	"	"	"	"	"	* Of this quantity 118.171 Sq. ft are completely finished, the remainder is unpolished
Embankment Steps	"	"	"	127008	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
Pedestals of Lions	19734	"	"		"	"	"	"	"	"	"	"	"	"	"	"	"	34224	"	"	
Channel	"	"	"		"	500966	399300	202112	"	194525	"	"	135000	"	290828	16250	"	"	"	"	
Embankments	"	"	"		"	2130206	755758	"	12195	289074	14250	50340	107875	"	"	"	"	"	17807	22800	
Total	311106	108342	48242	127008	156203	2755840	1381273	202112	22995	485421	14250	185340	174231	290828	16250	34224	17807	22800		

Earth rammed round quadrantal and other Steps and below Esplanade of Cattle Shut.
Revetments broken up for foundations of Lions. Lions commenced.
Clearance of Argillaceous deposit on Revetments.
Parapets of Rowtree Cattle Shuts commenced
Earthen Centering for main Arch Work dressed.
Earth Excavated below Canal bed for plastering and refilled.

APPENDIX
D

GENERAL INSTRUCTIONS
FOR
THE EXECUTIVE OFFICERS
OF THE
THIRD, FOURTH, FIFTH AND SIXTH DIVISIONS
OF THE
Ganges Ganal Works.

European establishment for supervision.

The establishment authorized for the executive supervision of each of the new divisions of works on the Ganges Canal is as follows:—

1 Executive Officer and 2 Assistant Executives.

Overseers, as they may be required, for the supervision of work; but only one in the first instance.

Ultimate limit of establishment as sanctioned.

2. The Schedule given in the margin* shews the limit of the permanent establishment as sanctioned by Government, but it will be understood that a portion only will be required at present, and that no addition to the numbers and salaries specified in the following paragraphs will be made without the special sanction of the Director of the works.

* ENGLISH OFFICE.			
1 European Accountant,	..	100 0 0	
1 English Writer,	..	45 0 0	
1 Assistant ditto,	..	25 0 0	
			170 0 0
NATIVE OFFICE.			
1 Moonshee,	..	30 0 0	
1 Assistant Moonshee,	..	15 0 0	
1 Native Surveyor,	..	25 0 0	
1 Native Doctor,	..	15 0 0	
2 Sowars at 15 Rs. each,	..	30 0 0	
1 Duffadar of Burkundauzes,	..	6 0 0	
4 Burkundauzes at 4 Rs. each,		16 0 0	
1 Chupprassy,	..	6 0 0	
2 Chupprassies at 5 Rs. each,	..	10 0 0	
4 Classies at 4 Rs. each,	..	16 0 0	
			169 0 0
TREASURY.			
1 Treasurer,	..	20 0 0	
1 Assistant Treasurer,	..	10 0 0	
1 Jemadar,	..	8 0 0	
1 Duffadar,	..	6 0 0	
16 Burkundauzes at 4 each,	..	64 0 0	
			108 0 0
WORKS.			
1 Mistry Smith,	..	25 0 0	
1 ditto Carpenter,	..	25 0 0	
1 ditto Bricklayer,	..	15 0 0	
1 Assistant Mistry Bricklayer,	..	12 0 0	
1 Jemadar of Chupprassies.	..	8 0 0	
10 Chuppraasies at 5 Rs. each,	..	50 0 0	
			135 0 0
Total Company's Rupees...			582 0 0

And permission to employ, with detached parties on works under overseers,
1 Moossuddie at 10 Rupees,
1 Chuprassy at 5 Rupees,
And a Guard proportionate to the Stores and Treasure in his charge.

3. English Office.—An Accountant and one English Writer will suffice in the first instance. Their salaries must depend on the nature of their qualifications. To secure the services of known and efficient men, the full salaries of 100 rupees and 45 rupees, respectively, may be given; but considering how small the expenditure and how simple the accounts will be for some time, I would prefer, in the first instance, that a young man be taken on trial as an Accountant on a salary of from 60 to 80 rupees per mensem.

English Office, as now required.

4. Native Office.—The undermentioned Native Office Establishment may be entertained at once.

Native office, as now required.

1	Moonshee,.....	at 20	rupees per mensem.
2	Native Levellers,	at 15 or 20	rupees ditto.
	(According to qualifications).		
1	Native Doctor,...	at 15	rupees per ditto.
2	Sowars, ...	15	rupees each, ditto.
1	Duffadar, ...	6	rupees ditto.
4	Burkundauzes, ...	4	rupees ditto.
1	Chupprassy, ...	5	rupees ditto.
2	Chupprassies, ...	4	rupees ditto.
4	Classies,.....	4	rupees ditto.

5. The Treasury Office and Guard will not at first be required.

Treasury Office not now required.

6. Works.—The Executive Engineer may entertain at once, 1 Mistry Smith, 1 ditto Carpenter, 1 ditto Bricklayer, at salaries not exceeding 15 rupees, for employment in the workshops; at 12 rupees, to superintend the building of the workshops and pucca bench-marks.

Establishment for Works.

7. Each Assistant or Overseer, detached, to have a Mootsuddie at 10 rupees, a Chupprassy at 5 rupees, and a guard of 4 Burkundauzes, of whom one would receive 5 rupees, the others 4 rupees per mensem.

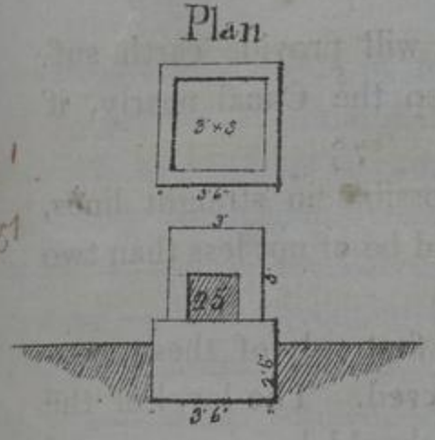
Establishment with detached Assistants and Overseers.

8. The first business of the Executive Officer will be to obtain by his own labor and that of his Assistants and native Levellers accurate information of the surface levels of the country throughout his division.

First business of the Executive Officer.

9. He will first select two masonry bench-marks, respectively at the upper and lower extremities of his district, as near the probable line of Canal as possible, using for this purpose, some distinguishable existing object not liable

A longitudinal line of levels to be first carefully laid down.



to displacement, or in the absence of such, he will build a masonry pillar of the form noted in the margin. The relative levels of these two points will be accurately ascertained by several trials, and the level of the upper one will be *provisionally* assumed as the zero, or starting point, for the general levels of the division.

These levels to be ultimately referred to that of the Myapoor regulating bridge.

10. In the foregoing paragraph I use the word "provisionally," because the levels of all the divisions must ultimately be referred to the sill of the Myapoor regulating bridge; and the Executive Engineer of the Munglour division, who has already referred his levels to the work above mentioned, as a zero point, will be instructed to fix the level of bench-marks at the south eastern extremity of his division on both sides of the *Kaleenuddee*, and to communicate these levels respectively to the Executive Officers of the Boolundshuhur and Futtehgurh divisions, who, having referred their levels to the same standard, will communicate the result to the next in succession: and so on.

Connected series of cross levels to be laid down.

11. In connection with the work above described, the Executive Engineer will take, or cause to be taken, a combined series of longitudinal and cross levels over the whole of his district. The proximity of these lines to each other will be regulated by the nature of the country, (whether undulating, flat, or having a uniform slope) but should be such as to mark clearly the principal water-shed lines, as well as all the lines of drainage.

Mode of exhibiting the result of the levels.

12. The results of this examination would be best exhibited on a map, drawn to a scale (say 4 inches to a mile,) that will admit of each level point being shewn, with its height (referred to the Myapoor zero) written in figures.

Specific object of the enquiry.

13. The object for which this information is required, and which therefore, should be kept steadily in view while collecting it, is to facilitate the selection of the best possible line for the main and branch Canals as well as for the irrigation channels or *Rajbuhas* for distributing the water to the villages.

14. In selecting the line for the main Canal, the following points will be carefully considered:—

Principal considerations in selecting the lines of main Canal.

I. To keep the Canal as much as possible on the highest ridge, so as to facilitate the distribution of water for irrigation, and not to interfere with the drainage of the country.

II. To ensure a depth of cutting which will provide earth sufficient for the requisite embankments, and keep the Canal nearly, if not entirely, "within soil."

III. To keep the Canal as much as possible in straight lines, and when a curve is unavoidable, that it should be of not less than two miles radius.

15. In selecting lines for *Rajbuhas*, the first only of these considerations need be observed. The level of the water in these channels should be as a general rule slightly *above* that of the adjacent lands, and their general direction would of course be regulated by the position of the villages to be irrigated.

Selection of lines for *Rajbuhas*.

Sig. 2. P. 113

16. In carrying on the series of levels above described, it is very important that permanent bench-marks should be established at short intervals, and where wells, tombs or small religious buildings may not be met with in localities suitable for this purpose, it will be advisable to build small blocks of masonry of the size and form noted in the margin, and numbered. It is evident that the utility of bench-marks will depend in a great degree on the facility and certainty of their identification, the means of which must therefore be carefully provided by the surveying officer.

Bench-marks to be established at short intervals.

17. When an existing building may be used as a bench-mark, a sketch of the building should be made in the Field Book with such a degree of accuracy and detail as would enable another person to recognize the object without difficulty. The part of the building on which the levelling stave is placed should be that least exposed to injury, and should be carefully marked in the sketch.

Existing buildings used as bench-marks to be accurately noted in the Field Book.

18. To obviate mistakes from indifferent drawing or the general similarity of wells, suttees, &c. the dimensions of one or two principal parts of the building should be accurately measured, and noted in the sketch. As an additional precaution, it would also be advisable to take compass-bearings from the bench-marks, to two or three conspicuous objects within sight.

Precautions against mistakes.

19. Where pillars of masonry are built as bench-marks, the numbers (which will be cut in 3-inch figures on the plaster in a niche or recess of the pillar,)

Means to be used for the identification of the pillars.

would afford a sure means of identification; but lest these numbers should be defaced, it would also be expedient to fix the position of the bench-mark, by bearings to conspicuous objects, as above described. The levelling stave should be placed both on the top of the pillar and on the plinth, and the level of both these surfaces should be recorded, as a precaution in the event of one of them being injured.

Uses to be made of the bench-marks.

20. Bench-marks, fixed with the care and precautions above prescribed, will be exceedingly useful for future reference, and as a check on the native levellers, whose work will always begin and close upon these fixed points, and may be received with confidence, when it is found to agree with a standard with which the operators were not previously acquainted.

Enquiries regarding building materials, &c.

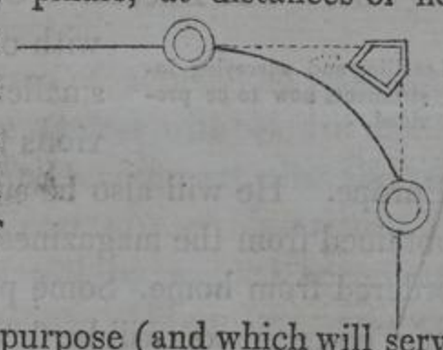
21. During the examination of the country, the attention of the Executive Officers, and assistants, should be directed to ascertain the localities and quality of building materials to be obtained in the district, such as kunkur, or marle, fit for the preparation of cements, block-kunkur suitable for building purposes, and brick, earth, &c. The value of different kinds of kunkur for cement, should be tested by experiment, and the result reported for the information of the Director.

Arrangements for bricks.

22. After the main line of Canal shall have been approximately fixed, arrangements may be entered into for the manufacture of bricks on that line, wherever fuel may be available; the quantity being regulated by a rough calculation of the requirements, according to the printed estimates, and with reference to the bridges, &c. required on *Rajbuhas*.

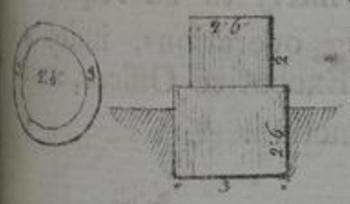
Main line to be carefully marked with masonry pillars.

23. When the direction of the main line has been definitely decided on, the central, or mesial line, should be laid down with the greatest care, and marked with small masonry pillars, at distances of not less than $\frac{1}{3}$ of a mile apart, so as to be easily visible, one from the other, and in cases of change of direction, a pillar would be built at each of the tangential points, and a third at the intersection of the tangents.



Description of pillars.

24. The pillars built for the above purpose (and which will serve as points of reference for levels as well as for direction) will be circular in plan, and of dimensions as per margin. Those at the intersection of tangents will be of a different pattern; thus:



25. The sites of the bridges and other masonry works would then be determined in communication with the Director, by whom specific instructions would be issued, regarding the details of their construction.

Bridge sites to be determined upon;

26. It will generally be advisable to construct the 1st and 2nd class chokies, as soon as the line of Canal and sites of bridges, have been determined.

and chokees built.

27. The exact length and longitudinal section of the main and branch lines of Canal being determined, the quantity of earth-work will be calculated, and an estimate will be framed and submitted to the Director, of the time probably required to complete the excavation, with reference to the resources of the country and facility of procuring contractors. The Director will then communicate his orders, regarding the period for commencing the work.

Estimate of earth work to be prepared.

28. In the Schedule of Establishment, in paragraphs 1 and 2, are included one European Overseer, a Blacksmith, and a Carpenter Mistry. The object of the early entertainment of these men, is the establishment of a workshop, at or near the place, where the Executive Officer may fix his head-quarters. The Blacksmith's department would be employed in the manufacture of tools, such as mamooties, (fourahs) pickaxes, felling axes, &c., and the Carpenters in the preparation of brick-moulds, soorkhi mallets, cubic measures for lime and soorkhi, 10 feet and 5 feet rods, wheelbarrows, &c.

Workshops to be established, and how employed.

29. The building for the workshops may be on the same general plan as that sanctioned for the Munglour division, of which I enclose a ground plan and elevation (Appendix A.) and for which an estimate must be submitted.

Nature of building for the workshops.

30. The Executive Officer will be provided, in the first instance, with one large levelling instrument, and as many smaller ones, up to six, as can be obtained, previous to the arrival of those commissioned from Europe. He will also be supplied with a theodolite, if such can be obtained from the magazines; otherwise, he will have to wait for those ordered from home. Some pairs of levelling rods (probably as many as may be required) will be forwarded from the Director's Office.

Levelling and surveying instruments how to be provided.

31. For iron measuring chains, and as many mamooties, felling axes, &c. as are likely to be required in carrying on the levelling operations, indents on the nearest magazine will be prepared by the Executive Officer, and transmitted through the Director's Office, for sanction.

Certain indents to be submitted.

Bills for salaries of establishment how prepared.

32. Bills for establishment salaries will be submitted monthly in the usual form, the general authority being quoted in the heading, and the special authority for any change or increase of salary being separately stated. The usual form of attestation will be appended to the bill, which must also be accompanied by acquittance rolls, in English and Persian, signed or sealed by each of the establishment in the receipt of a salary amounting to 10 rupees a month or upwards. The names as well as the designations of all the establishment receiving 10 rupees a month or upwards, must also be entered in the body of the bill.

Expenditure on works to be charged quarterly.

33. All expenditure on works will be charged and submitted quarterly, agreeably to the appended copy of "Rules" (Appendix B.) promulgated by Government, North Western Provinces, and communicated to me in Mr. Secretary Thornton's letter No. 500 A. of the 25th August, 1847.

Form of the quarterly bills.

34. The first bills will consist of little more than the contingent expenses of surveying, but when there may be occasion to charge for work admitting of measurement, the bill will be prepared in the usual departmental form, and will consist of a statement of expenditure on labor and materials (separately) for each work, an exhibition of the rates at which each description of work was actually executed, and a comparison of the actual and estimated rates.

Measurement of work and survey report.

35. To each bill will be appended a statement of measurements of the work charged for, and a survey report in the usual form.

Detail of the quarterly bills.

36. The whole quarterly expenditure, though included in one bill, will be shown in separate items specifying the several descriptions of work on which it was incurred. The precise detail of this sub-division, for each principal work, will be prescribed by the Director.

The rates to be deduced *bonâ fide*.

37. In preparing the comparison of actual and estimated rates, the Executive Officer will bear in mind, that it is the object of Government, that the rates exhibited should be those of the *actual* cost of each description of work. The heading of this part of the bill will be worded accordingly, and the attestation, on honor, will be held to apply to the rates as well as the amounts charged.

Explanation of differences.

38. The "comparison of rates" will be followed by an "explanation of differences," in all cases where there may be a discrepancy, one way or the other, between the estimated and actual rates.

39. The expenditure on materials will be brought forward in the manner described in clause IV. and in paragraphs 5, 6 and 7, of clause III. of the annexed "Rules."

Expenditure on materials.

40. The accounts of expenditure kept by the Executive Officer and required by him from his subordinates, must be closed monthly, and will be prepared with special reference to the system of accounts embodied in the Agra Government "Rules."

Accounts to be kept by the Executive Officer.

41. The forms prescribed by the Military Board for the accounts of the Department of Public Works, are appended to this commucication (Appendix C.) but a modification of this system has been generally adopted in the Canal Department.

Forms of accounts prescribed by the Military Board.

42. The "Day Book," as prescribed, is intended to be sent in daily to the Executive Officer, and this would be attended with much advantage, where extensive works are being carried on at one spot under the immediate supervision of the Executive Officer. As, however, it generally happens in the Canal Department, that the expenditure is incurred by assistants or overseers at different localities, and not under the immediate supervision of the Executive Officer, whose duty it is to control the whole, it has been found convenient in practice to combine all the information contained in the "Day Book" in a monthly statement, the form of which is appended (see Appendix D).

Modification of these forms adopted in the Canal Department.

43. The only real difference between this method and that of the Department of Public Works, is that the expenditure is reported, in the one case daily, in the other monthly, to the Executive Officer; the degree of detail in both plans may be the same.

Difference between the two methods.

44. The precise form in which the daily expenditure shall be reported to the Executive Officer, is left in some measure to his own discretion, under the proviso that the accounts of all his subordinates shall be susceptible of easy check, and that they, as well as the books prepared from them in the Executive Engineer's Office, shall contain all the details of information expected or required by the Military Board or by Government.

The accounts to contain all the information required.

45. A list of periodical papers, to be transmitted to the Director's Office, is subjoined. (See Appendix E.)

List of periodical papers.

46. Whenever it may be necessary to take up ground for Canal purposes, or to cut down trees, or remove wells or buildings, interfering with the line of Canal, the

Rules for compensation.

proprietors of such land, trees or buildings, will be entitled to compensation, which will be awarded in strict accordance with the rules laid down in Mr. Secretary Thornton's letter to the Sudder Board of Revenue, No. 360, of 27th January, 1845, a copy of which forms Appendix F.

Assistance from the Civil authorities of districts.

47. In accordance with the instructions of his Honor the Lieutenant-Governor, North Western Provinces, communicated to the Sudder Board of Revenue, N. W. P., under date the 25th August, 1847, the Revenue Officers of the districts through which the Ganges Canal will pass, have been apprised of the approaching commencement of the work, and have been directed to afford every necessary assistance to the Officers of the Canal in their progress through the country. It must be understood, however, that the Executive Engineers are not to rely upon the assistance of the Civil Officers, to procure labor or carriage for the works. These will be generally obtainable by good management, and by a system of regular payment and considerate treatment of the parties employed.

Due respect to be paid to Native Revenue and Police Officers.

48. The Executive Engineers will impress upon all their subordinates the necessity of treating with the consideration due to their official functions, the Native Officers of the Revenue and Police departments, with whom they may be brought in contact, in the discharge of their public duties.

Contract work recommended.

49. In the execution of work, it is advisable to adopt a system of contracts, whenever such can be obtained on reasonable terms. The works most easily susceptible of contract, are, the excavation of a cut or formation of an embankment, of a given section; manufacture and carriage of bricks, lime and *soorkhi;* quarrying and carrying blocks of *kunkur*, &c.

Remarks upon hired labor.

50. When hired labor is employed, that supplied by the neighbouring villages, and paid daily, is generally the most economical; but when larger parties are required than the neighbourhood can supply, or when any particular work is in progress, (such as block-sinking) which requires practised workmen, it then becomes necessary to employ laborers (*bildars*) on monthly pay, and to enforce strictly a system of task-work.

Organization and description of *bildars*.

51. The *bildars* should be divided into *mudduts*, or squads of 30 to 40 men each, under charge of a tindal, who will receive 6 rupees per mensem, and who will be generally held responsible for the conduct of

his men, and may be punished for their remissness, at the same time that his authority is strictly upheld.

Collective preferable to individual tasks.

52. It will be generally found advisable to assign collective rather than individual tasks, *i. e.*, to measure out a certain portion of work to a whole squad, and not to each *hildar*. On this plan, each man has a direct interest in seeing that the others work, and in preventing truancy and skulking.

Terms on which absence on the plea of sickness can be granted.

53. When large parties of monthly paid laborers are employed, it is important that the terms on which absence on the plea of sickness can be allowed, should be well understood. The method in use in the northern division of the Ganges Canal, is recommended for general adoption. It is as follows:

Hospital accommodation is provided for the work people in the event of sickness. Men, who have been injured on the works, receive full pay during their hospital treatment. The other hospital patients receive half-pay. Men who absent themselves from work under the plea of sickness, but do not go into hospital, receive no pay while non-effective.

Indents for stationery.

54. The Executive Engineers of the Ganges Canal are supplied with stationery from the Government stores, on which an indent, prepared agreeably to the accompanying form, (see Appendix G.) should be submitted through the Director's office, as soon as possible after the 1st July of each year.

Decisions on references on different subjects.

55. To prevent the necessity of future references, I subjoin (Appendix H.) a list of questions which have been referred from time to time by Executive Officers, and the authoritative decisions thereon, in parallel columns.

W. E. BAKER, Major,
Director, Ganges Canal Works.

Roorkhi,
September 30th, 1847.

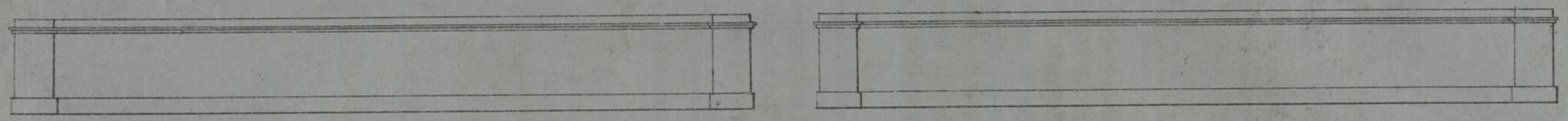
APPENDIX A.

GENERAL PLAN of WORKSHOPS

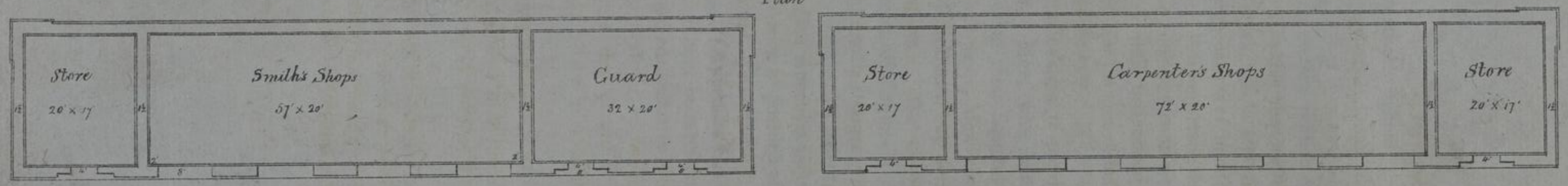
for the

GANGES CANAL

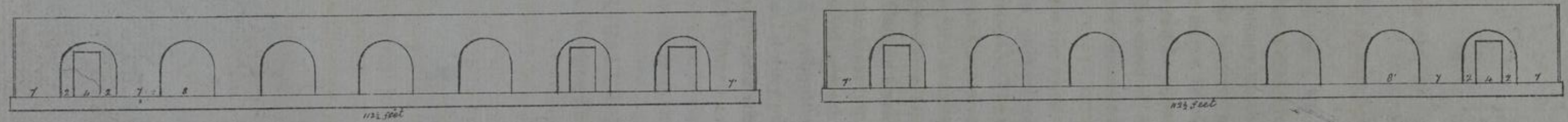
Front Elevation



Plan



Rear Elevation



Section

APPENDIX B.

RULES FOR KEEPING THE ACCOUNTS ON THE GRAND GANGES CANAL.

I. The works shall be executed agreeably to Major Cautley's designs. No deviation from the principles which have been sanctioned by Government to be made without the previous approval of the Military Board. The Director will be competent to authorize such modifications as may be necessary to the efficiency of the work in progress, reporting the same immediately to the Military Board.

II. When money is required for the execution of works, application will be made by the Executive Engineer, through the Director, to the Accountant, North Western Provinces, who will issue an assignment for the amount.

III. For the Northern Division.

The Executive Engineer of *Works* will submit to the Director a bill for three (3) months' work prepared in the usual departmental form, i. e. exhibiting quantities, rates and amounts, and accompanied by detailed measurements of work done.

2. The materials used to be charged for on rates furnished by the Executive Officer of *Materials*.

3. When the rates of work differ from the estimated rates, full explanations to be given at the foot of bills in the usual manner.

4. The bills after careful examination by the Director will be submitted with his remarks to the Military Board.

5. The Executive Officer, whose duty will be to collect and prepare materials and to take charge of bullocks, carts, &c., will submit quarterly to the Director for transmission to the Military Board, a detailed statement of expenditure and results in each item of his charge including carts and bullocks, accompanied by such explanations as may appear to be necessary.

6. To the above Statement will be appended a balance sheet, shewing on one side the actual expenditure on each item, and on the other the amounts received from the Executive Engineer of Works, and the stock in hand.

7. He will also submit a list deduced from the above mentioned accounts of prices of materials, bullock hire &c., which he proposes to charge during the ensuing quarter, to the Executive Engineer, to whom it will be communicated by the Director, if approved.

8. The Executive Officer for Materials will get advances from the Executive Engineer of Works and will write off per contra, the value of materials supplied.

IV. In the smaller divisions it may be expedient from motives of economy to unite in one Officer the functions of the two allowed to the 1st Division.

2. The Executive Engineer of a smaller division will therefore keep and submit quarterly to the Director, distinct accounts of works and materials as laid down for the *two* Officers of the 1st division.

V. On completion of any work extending through more than one quarter, the Director will draw out and submit to the Military Board a comparison of its actual cost with that estimated, at the same time reporting on the quality of work, &c. &c. Every work commenced and completed within the quarter, will, by the Director, be separately reported on, as to its quality, &c.

VI. General accounts, of expenditure on the Canal works of all descriptions, will be kept in the Director's Office, and balance sheets will be submitted to Government, quarterly or half yearly, as may be required.

J. THORNTON,

Secy. to Govt. N. W. Provinces.

APPENDIX C.

Forms to be observed by BARRACK MASTERS *in keeping Accounts; approved and adopted by the* MILITARY BOARD, *on the* 1*st May*, 1821.

As an uniform system of accounts should be adhered to throughout the Barrack Department, the following forms are selected as the most convenient, with reference to the documents required to accompany bills for work executed.

Each district Barrack Master must keep five Books, viz. No. 1, a Journal or Day Book, No. 2, an Abstract of Daily Cash Payments, No. 3, an Abstract of the Daily Expenditure of Materials and Labor, No. 4, a Stock Book, and No. 5, a Book for Advances in the shape of an Account Current.

In Book No. 1, all the disbursements of every description must be inserted each day, under its proper head; when a payment is made for general purposes, and not for any particular building, it must be entered under that head.

Book No. 2 is intended for easy reference. The horizontal columns shew at one glance of the eye the amount expended each day on the several works, as well as the total expense of the day. The vertical columns, when added up, shew at once the total sum expended on any work up to any fixed date, as well as the total expenditure. This book, by being kept up regularly, will be found to save much time.

Book No. 3 is intended to record the labor and materials expended each day on different parts of the same buildings. For this purpose several pages or half pages must be allotted to one building, viz. half a page for the foundations, one or more pages for the superstructure, roof, floor, cornice, &c., &c. It affords the means of adding up separately and readily the expenditure on each part of a building, and when this book is accurately kept, nothing is more simple than the making out the bill, at the completion of the work. All that is required, is, to take the total of each description of work, and the bill is ready. No. 4 is to shew readily what materials have been purchased, the average cost of them, and their appropriation. No. 5 is the same description of book, but has reference to individuals, instead of materials; it is a personal account current with each Contractor, Merchant, Agent, or Head Mechanic, shewing what advances have been made and what has been received for the money, or what is due. Each account with a native must be balanced monthly, and the man's

signature affixed, or his acknowledgment of its being correct tacked to it. With Europeans it may be sufficient to balance the account quarterly. The book No. 3 cannot be kept accurately, unless a sufficient number of Lallahs or Mohurrurs are kept at the works, to see what labor and materials are used, and to send to the office a daily Report in writing which should be filed as soon as it has been entered in the books.

Experience has shewn that the first expense of keeping up a sufficient number of writers is amply compensated by the advantages of an early adjustment of accounts, and it will be readily seen that it is much easier to write a few lines in the books daily, than to have intricate accounts to make out when any work is finished; and in the event of any sudden removal or any accident occurring to a Barrack Master, his successor will easily continue the accounts and adjust all claims. A set of books of the prescribed form must be kept at each post, or station, and when this cannot be done in the English language, it must be done in Persian or Bengalee.

When money is sent to a native Agent or Overseer to carry on works at an outpost he must be ordered to send regular monthly accounts, and to shew by the attestation of the parties concerned, that all advances on account, have been regularly balanced and adjusted for the past month. Receipts in duplicate for all advances must be regularly executed.

No. 1.

Form of Day Book.

1816 February			Rs.	A.	P.	Rs.	A.	P.
		STABLE No. 2 LINE.						
	1	1 Mate Mason, ...	0	4	0			
		44 Masons @ 2½ annas each, ...	6	14	0			
		27 Bildars @ 3¾ pice each,..	2	15	8			
		105 Coolies 1st @ 2½ annas each, ...	7	11	6			
		35 Ditto 2nd @ 1 anna each, ...	2	3	0			
		19 Boys @ 2 pice each, ...	1	2	11			
		1 Mate Bheestie, ...	0	2	6			
		15 Bheesties @ 2 annas each, ...	1	14	0			
		10 Bundaries, ...	1	4	0			
		1 Mate and 8½ Carpenters @ 2½ as. each,	1	8	3			
		6 Sawyers, ...	0	15	0			
		16 Chakees, ...	4	15	4			
						31	13	2
		STABLE No. 4 LINE.						
		1 Mate Mason, ...	0	3	0			
		12 Masons @ 2½ annas each, ...	1	14	0			
		15 Bildars @ 3¾ pice each, ...	1	10	6			
		27 Coolees 1st @ 2½ each, ...	1	15	9			
		7 Ditto, ...	0	0	0	5	11	3
		Total expended 1st February, as per figured Cash Abstract, ...				37	8	5
		ADVANCES FOR GENERAL USE OF THE DEPARTMENT.						
	2	To Shaek Ramjaun, for lime, ...	300	0	0			
		„ Googee Churn, Mistry, for bricks, ...	200	0	0			
		„ Jugun Churn, ditto for firewood, ...	50	0	0			
		„ Ramgeeon, for Soorkhie, ...	20	0	0			
						570	0	0
		WORKMEN.						
		Quarter Master Sergeant's House, Infantry Lines.						
		1 Mate Mason, ...	0	4	0			
		50 Masons @ 2½ annas each, ...	9	8	0			
						9	12	0
		HOSPITAL OF 2ND BATTALION 9TH.						
		1 Mate Mason, ...	0	4	0			
		61 Masons @ 2½ annas each, ...	9	8	6			
						9	12	6
		CANTONMENT ROAD.						
		7 Bildars, ...	0	14	0			
		2 Ditto boys, ...	0	3	0	1	1	0
		Total Expended 2nd February, ditto				590	9	6
	3	Advanced to John Ullee, Native Agent at Mullye, ...	100	0	0			
		Ditto to Lallah Gunga Ram, at Kishen Gunj, ...	50	0	0			
		Ditto to Goolmahomed ditto Chuppra,	500	0	0			
						650	0	0

No. 2.

Form of Cash Abstract of Daily Cash Payments.

Date.	Stable No. 2.	Stable No. 4.	Quarter Master Sergeant's house Infantry lines.	Hospital 2nd Battalion 9th Regiment.	Cantonment Road.	Advances for general use of the department.	Kunkur.	Lime kiln.	Magazine.						Total disbursements each day. For particulars—See Day Book.
1816, Feby. 1st	31 13 2	5 11 3	0	0	0	0	0 0	0	0						37 8 5
2nd	0	0	9 12 0	9 12 6	1 1 0	570	0	0	0						590 9 6
3rd	0	0	0	0	0	650		0	0						650 0 0
	4	1	1	1	1	1	2	1	1	1	1	1	1	1	5

No. 3.

Figured Abstract of Daily Cash Expenditure of Labor and Materials.

No. of feet.	Description of building.	Head Masons.	Masons.	Bildars.	Coolies, 1st.	Coolies, 2nd.	Boys.	Bheesties.	Carpenters.	Sawyers.	Grammies.	Bricks.	Lime.	Sand.	Soorkhi.		Total Expense.		
C. feet.													*mds.*	*mds.*	*seers.*				
192 9	Foundation wall, 19th December, 1815, ..	1	3	5	4	1	3	1	0	0	0	1000	2	3	20				
		4	5	10	6	1	1·6	2	0	0	0	5	1-8	1-8	3		10	0	6
257 3	Do. do. 20th do. ditto, ...	1	3	4	4	1	3	1	0	0	0	500	1	1½	20				
		4	7·6	8	6	1	1.6	2	0	0	0	2-8	12	12	3		6	1	0
480	Total cubic feet in foundation, ...																16	1	6
200	Superstructure, 21st December, .. .	0	0																
210	Do., 22nd ditto, . ..	0	0																
		0	0																
210	Do., 23rd ditto, ...	0	0																
620	Total cubic feet in superstructure, ...																		
300	Plaster wall, 23rd December, ...																		
250	Roof Do., 23rd December, ...																		
230	Cornice Do., 23rd December, ...																		
230	Total running feet of cornice, ...																		

No. 4.

Form of Stock Book.

1815, January,	0	000 Bricks, received from Ramjaun, Brick Contractor, at 00 per 0000, ...	0 0 0	1815, February,	0	000 Bricks issued for the Quarter Guard of the 9th Regiment Native Infantry, at 00 per 000,	0 0 0
				March,	1	Balance in store, ...	0 0 0
				May,	0	000 Maunds Lime issued for white washing Artillery Barracks, at per 100 maunds, . ..	0 0 0
March,	0	000 Maunds of Lime, received from Mr. A. B., at 00 per 100 maunds, ...	0 0 0	May,	0	000 Maunds Lime despatched to Captain A. B., for commercial Buildings at Malda, at per 100 maunds, ...	0 0 0
				June,	1	Balance in store, ...	
March,	0	000 Ferrahs of Kooah received from C. D., Contractor, at per 100 Ferrahs, ...	0 0 0	April,	0	000 Ferrahs of Kooah issued for the Cantonment road at per 100 Ferrahs, ...	0 0 0
						Balance in store, ...	0 0 0
April,	0	000 Saul Timbers, received, &c, &c, ...	0 0 0	June,	0	000 Saul Timbers issued, &c, ...	0 0 0
						Balance in store, ...	0 0 0

No. 5.

Form of a Book for Advances in the shape of an Account Current.

		Mr. A. B., Lime Contractor. Dr.				Mr. A. B., Lime Contractor. Cr.	
1819, June,	0	To amount advanced to you in cash as per Re-		1819, June,	0	By 000 Maunds of Lime delivered at per 000	
		ceipt, ...	0 0 0			maunds, ...	0 0 0
July,	0	„ Ditto, Ditto, ..	0 0 0	July,	0	By 000 maunds of Lime to Malda, Ditto,	0 0 0
August,	0	„ Ditto, Ditto, ..	0 0 0	August,	0	By 000 maunds of Lime to Malda Diito,	0 0 0
			0 0 0				0 0 0
			0 0 0			By Balance due to Barrack Department, ..	0 0 0
			0 0 0				0 0 0
		Ramtonoo, Brick Contractor. Dr.				Ramtonoo, Brick Contractor. Cr.	
June,	2	To amount advanced to you in Cash as per Re-		June,	9	By 000, 11 inch Bricks delivered at ..	0 0 0
		ceipt, ...	0 0 0	„	23	By 000, 12 inch Bricks ditto ..	0 0 0
				„	30	By 000, 11 inch Bricks ditto ..	0 0 0
							0 0 0
				July,	1	By Balance due to Barrack Department, ..	0 0 0
		(Signed) C. D., *Brick Contractor.*				(Signed) A. B., *Barrack Master.*	

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Vol III

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GANGES CANAL WORKS ———— DIVISION.

Daily Account of Work People employed and materials used, on the undermentioned works, during the month ———— of 1847.

| | No. 1.—Regulating Bridge. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | No. 2.—Excavation in the Canal for Railway. | | | | | | No. 3.—Excavation for Channel of the earthen aqueduct. | | | | | | | | No. 4—Bricks. | | | | No. 5.—Bridge centerings | | | | | | | | | | | | | | | | | | No. 6.—Excavation for embankment. | | | | |
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GANGES CANAL WORKS —— DIVISION.

Abstract of Workmen employed and materials used on the undermentioned works during the month of —— 1847.

No.	Description.	Masons at 8.	7-8.	7.	4.	3-8.	3.	2.	1.	Mistrees at 9.	Mates at 8.	7.	6.	Classies at 4.	Bildars at 4.	Carpenters at 10.	8.	7-8.	7.	6.	Materials. 2½ Inch bricks.	Lime.	Soorkhi.	Sand.	Rope.	Oil.	Earthen vessels.	Bullocks.	Baskets.
																									sr.	sr.			
1	Regulating Bridge, ...	280	310	70	2	4	4	24	8	0	0	19	87	16	3,650	0	0	0	0	0	66,308	676	676	676	0	6¼	74	56	747
2	Excavation in Canal for Railway, ...	0	0	0	0	0	0	0	0	0	2	52	30	0	2,521	0	0	0	0	0	0	0	0	0	0	0	0	0	275
3	Do. for channel of earthen aqueduct, ...	0	0	0	0	0	0	0	0	19	11	120	225	30	12,758	0	0	0	0	0	0	0	0	0	0	0	0	0	897
4	Brick kilns, ...	0	0	0	0	0	0	0	0	0	0	15	3	0	731	0	0	0	0	0	0	0	0	0	0	0	0	0	69
5	Bridge centres, ...	0	0	0	0	0	0	0	0	0	0	0	10	0	349	4	23	18	16	2	0	0	0	0	1	0	0	0	0
6	Excavation for embankment,	0	0	0	0	0	0	0	0	0	0	8	43	79	0	5,151	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total, ..	280	310	70	2	4	4	24	8	19	21	249	434	46	25,160	4	23	18	16	2	66,308	676	676	676	1	6¼	74	56	1,988

1 12½ 2 - 1 2 - 1 3 1 - - - 3 2 - - 1 - - 3

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APPENDIX E.

List of Periodical Papers.

Monthly.

Statement of correspondence.
List of letters despatched by Executive Engineer.
Estimate of Funds required by Executive Engineer for the current and five ensuing months.
Report on disposal of Assistants.
Progress Report.
Current Expense Bill.
Statement of Assignments received and realized during month.

Quarterly.

Return of Warrant and Non-commissioned Officers' Bill for expenditure on Works, with Abstracts of quantity completed, &c.

Half Yearly.

General Sayer Account, to Accountant N. W. P., and Director.

Yearly.

Indent for Stationery.
Return of Magazine Tools.
Return of Levelling and Surveying Instruments.
Descriptive Roll and confidential Report of Overseers.
Return of Uncovenanted Servants.

GANGES CANAL WORKS —— DIVISION.

Progress Report on the undermentioned Works during the Month of —— 1847.

No. 1.—Regulating Bridge.

Part of Work.	Description.	L Feet.	L Inches.	B Feet.	B Inches.	D Feet.	D Inches.	Number.	Contents c.ft.	Contents in.
Pillars, ..	Brick Work Masonry mortar, 1 Lime, 1 Soorki, 1 Sand,	5	6	5	6	2	9	4	332	9 0
ditto, ...	ditto, „	5	0	5	0	1	3	4	125	0 0
ditto, ...	ditto, „	5	6	5	6	0	9	4	90	9 0
ditto, ...	ditto, „	5	0	5	0	0	6¾	4	56	3 0
ditto, ...	ditto, „	9	6½	4	1½	2	9	2	216	5 7
ditto, ...	ditto, „	9	0½	3	7½	1	3	2	81	11 3
ditto, ...	ditto, „	3	7½	3	7½	1	3¾	2	34	5 10
ditto, ...	ditto, „	4	2½	4	7½	1	3¾	2	51	0 10
ditto, ...	ditto, „	7	1½	0	3	0	9	2	2	8 0
ditto, ...	ditto, „	9	7½	1	0	1	9	2	33	8 0
Pier, ...	ditto, „	6	4½	3	1½	1	7	2	63	0 10
Pillar Walls, .	ditto, „	5	7½	2	4½	7	9	2	206	11 10
ditto, ...	ditto, „	7	8	0	3	1	0	2	3	10 0
Cutstone, cornice,	ditto, „	10	0	1	0	1	5	2	28	4 0
Pillar Walls, ..	ditto, „	2	3	2	3	9	4	2	94	6 0
Parapet, ...	ditto, „	10	9	2	6	2	0	2	107	6 0
ditto, ...	ditto, „	7	0	2	0	3	9	2	105	0 0
ditto Cornice,..	ditto, „	4	3	2	3	1	0	2	19	1 6
ditto, ...	ditto, „	2	0	1	9	1	3	2	8	9 0
Wing Wall Cornice, ...	ditto, „	29	3	3	0	1	9	4	614	3 0
ditto, and bench	ditto, „	29	3	5	6	1	0	4	321	9 0
ditto, ...	ditto, „	29	9	1	6	1	3	4	223	1 4
ditto, ...	ditto, „	29	3	2	0	0	10½	4	204	9 0
Bench, ...	ditto, „	29	3	2	0	0	6	2	58	6 0
ditto, ...	ditto, „	29	3	1	9	1	0	2	102	4 6
Wing Wall, ..	ditto, „	29	3	2	0	1	0	2	117	0 0
Pillar, ...	ditto, „	7	0	4	8½	2	9	2	181	3 2
ditto Cornice, ..	ditto, „	12	0	1	0	1	9	2	42	0 0
ditto, .. .	ditto, „	6	6	4	2½	2	6¾	2	140	2 3
ditto Cornice,..	ditto, „	9	0	0	3	0	9	2	3	9 0
Piers, ...	ditto, „	4	1½	2	5½	4	6	9	410	10 6
Walls to crown of Arch, ...	ditto, „	12	0	2	6	4	6	9½	1282	6 0
ditto, ...	ditto, „	12	0	2	6	1	7	10	475	0 0
ditto, ...	ditto, „	6	2½	4	1½	1	7	9	365	9 9
Arch, ...	ditto, „	41	9	9	9	1	6¾	0	636	0 7
ditto, ...	ditto, „	41	9	23	4	1	6¾	0	1522	1 5
								Total Contents,	8363	5 2
Deduct Piers, ..	1′ 1″ × 1′ 1″ × 1′ 7″ × 9 = 16′ 8″ 8‴									
Do. Do.,.. ..	1 1 × 1 1 × 4 6 × 9 = 47 6 6									
Do. Do. Grooves,	1 0 × 0 9 × 1 7 × 9 = 10 8 3								74	11 9
Balance Total Cubic Feet of Masonry, ...									8288	5 9

16,992 Cubic Feet of Excavation done in making Roadway across arches, ... L 177 × B 32 × D 3 = 16992 C. Ft.

No. 2.—Excavation in Canal for Roadway.

	L	B	D	
Earth Excavated, ...	548·14	× 50	× 5	= 1,39,035 Cubic Feet.

No. 3.—Excavation for Channel of Earthern Aqueduct.

	L	B	D	
Earth Excavated, ...	4590·64	× 50	× 3	= 6,88,596 Cubic Feet.

No. 4.—Brick Kilns.

30,000 Pucca Bricks taken out of Kiln,.. .. .... 12″ × 6″ × 2½″
83,308 Peela Do. Do., ... 12 × 6 × 2½

No. 5.—Bridge Centres.

Centres, Planks, &c., all taken down and sent into store and planks all stacked at Shop.

No. 6.—Excavation for Embankment.

	L	B	D	
Earth excavated, ...	4353	× 25	× 4	= 4,35,300 Cubic Feet.

GANGES CANAL WORKS —— DIVISION.

Abstract of Expenditure during the month of —— 1847.

Description.	Rate.	Amount price.	Amount.	Total.	Grand total.
Work People.	*R. A.*				
280 Masons at per month,	8		74 10 8		
310 ditto .... ditto, ..	7-8		77 8 0		
70 ditto .. . ditto, ..	7		16 5 4		
2 ditto .... ditto, ..	4		0 4 3		
4 ditto .... ditto, ..	3-8		0 7 5½		
4 ditto .... ditto, ..	3		0 6 5		
24 ditto .... ditto, ..	2		1 9 7		
8 ditto .... ditto, ..	1		0 4 3		
19 Mistrees .. ditto, ..	9		5 11 2½		
21 Mates .... ditto, ..	8		5 9 7		
249 ditto .... ditto, ..	7		58 1 7		
434 ditto .... ditto, ..	6		86 12 9½		
46 Classics .. ditto, ..	4		6 2 1½		
25,160 Bildars .. ditto, ..	4		3,354 0 8		
4 Carpenters ditto, ..	10		1 5 4		
23 ditto .. . ditto, ..	8		6 2 1½		
18 ditto .... ditto, ..	7-8		4 8 0		
16 ditto .... ditto, .	7		3 11 2½		
2 ditto .... ditto, ..	6		0 6 5		
			——	3,704 9 0	
Materials withdrawn from store.					
66,308 2½ inch pucca bricks, ..					
676 cubic feet Lime, ..					
676 cubic feet Soorkhi, ..					
676 cubic feet Sand, ..					
56 Govt. Bullocks in use,					
Materials purchased.					
1 seer Rope at 2 seers per rupee,			0 8 0		
6¼ seers Oil at 6¼ seers per ditto,			1 0 0		
74 Earthen vessels, each,	2 p.	72	2 0 10		
1,988 baskets at 2 Rs. per 100,			39 12 1		
			——	43 4 11	
Total expenditure, Company's rupees, ..				3,747 13 11	

GANGES CANAL WORKS —— DIVISION.

Account Current of Expenditure for the month of ——— 1847.

Date.	Dr.	Amount.			Total.			Date.	Cr.	Amount.			Total.		
1847,	To Balance in hand on 1st ——							1847, 1	By Amount expended during the						
	as per last Account Current,..	500	4	0					month of ——— as per Ab-						
17	To Cash received from ..	1,500	0	0					stract, ...	3,747	13	11			
20	To Ditto, ...	2,000	0	0				30	By Balance in hand,....	252	6	1			
					4,000	4	0						4,000	4	0
	Total Company's rupees, ..				4,000	4	0		Total Company's rupees,....				4,000	4	0

APPENDIX F.

No. 360.

FROM

J. THORNTON, ESQUIRE,

Secretary to the Govt., N. W. P.,

TO

H. M. ELLIOT, ESQUIRE,

Secretary to the Sudder Board of Revenue, N. W. P., AGRA,

Dated, the 27th January, 1845.

Revenue Dept.

SIR,

With reference to the correspondence noted in the margin, * I am desired to request that you will inform the Board that the Lieutenant Governor, on the occasion of his late visit to Hurdwar, found that some difficulty and delay were still experienced in adjusting the amount of compensation for property required for the Ganges Canal. Advantage was taken of the presence on the spot of all the Local Revenue and of the Canal Officers, to come to a better understanding on the subject.

* Letter to Secy. Sudder Board of Reve., dated 4th June, 1844, No. 2111.
Letter from ditto ditto, dated 2nd July, 1844, No. 309.
Letter to ditto ditto, dated 20th July, 1844, No. 2726.
Letter from Comr. Meerut Division to Secy. Sudder Board of Revenue, No. 216, dated 24th July, 1844.
Letter to Secy. Sudder Board of Revenue, No. 3956, dated 7th Sept., 1844.

2. The great object to be attained is promptitude in the adjustment of all claims of this nature, and security that payment for property taken, or suspension of demand for land occupied, be not delayed when the right of the claimant has once been recognized.

3. These ends will generally be best attained by entrusting the award of compensation to the Canal Officers, who are on the spot, but it is found that, with regard to property in land, those Officers have difficulty in ascertaining the principles on which remission of the Government demand on the land is to be adjusted, or the persons who are entitled to claim the benefit of compensation on account of the land occupied by the Government. With respect therefore to this class of claims, the agency of the Collector must still be employed, and due provision made for fixing on the right party the responsibility for any delay which may occur.

4. The Lieut. Governor therefore proposes the following rules for adoption, and requests that they may be communicated through the Commissioner and Director of the Canals to those whom they may concern, unless the Board are aware of any objections to their immediate adoption.

5. The Canal Officers shall settle all compensation regarding houses, trees, crops, wells and buildings, and shall pay the money from their own Treasury, taking receipts as vouchers and acquittances from the owners. The Revenue Officers are always at liberty to represent any case in which they find the compensation awarded to be inadequate, or the proceeding to have been conducted in any objectionable way.

6. The Collector shall settle compensation regarding land, however occupied, whether by crops, or gardens, whether cultivated, culturable or barren, whether *khalisah* or *lakhraj*. In such cases, the Canal Officer as soon as he has laid down his line, (*takh bell*) should give certificates to the Tehseeldar and Collector stating the quantity of land he requires and which he has marked off, and the date on which he requires that it be vacated. This date should generally be that on which all the standing crops will be cut at the termination of the current Fussily year. It will then rest with the Tehseeldar immediately to ascertain and report to the Collector how and by whom the land is occupied, and on what terms remission of jumma or compensation should be given, under existing rules. It will rest with the Collector to provide that the terms be definitively settled by the time when the land is required by the Canal Officers, or as soon after as possible, and that no unnecessary demand is made on the Zumeendars for the land thus taken. The Collector, when reporting to the Commissioner his proposed remission for the confirmation of Government, will furnish a copy of his report to the Director of the Canal, in order that an opportunity may be afforded to that Officer of offering any remarks on the transaction that may occur to him as affecting the charge on his works.

7. The remission ultimately sanctioned by the Government will be notified to the Director of the Canal at the same time as to the Accountant, Revenue Department.

8. The Lieutenant Governor requests that the Board will impress upon the Commissioner and the Director of the Canal the importance of paying attention to the regular and punctual performance of this duty.

I am, &c.

J. THORNTON,

Secy. to Govt., N. W. Provinces.

Agra, the 27th Jany., 1845.

APPENDIX G.

Indent for Stationery required for the use of the Executive Engineer of the —— Division of the Ganges Canal, ———————— 1st July, 18—.

Names of Articles.	Received in December, 1846.			Balance on the 1st July, 1847.			Quantity Indented for, for 1848.			Number of Clerks, Assistants, &c.	Remarks.	Admitted.
	Rm.	Quires.	No.	Rm.	Quires	No.	Rms.	Quires	No.			
Double Elephant drawing paper, ...												
Book paper, . ..												
General Letter paper, ...												
Foolscap paper, ...												
Quarto Post do., ...												
Blotting paper, ...												
Serampoor paper, ...												
Marble paper, ...												
Cartridge paper, ...												
Quills, ...												
Black Ink powders, ...												
Red Ink powders, ...												
Penknives, ...												
Erazers, ...												
Hones, ...												
Strops, ...												
Slices, ...												
Scissors, ...												
Office Pencils, ...												
Drawing Pencils, ...												
Red Tape, ...												
Indian Rubber, ...												
Chest Inkstands, ...												
Round Rulers, ...												
Wafers, boxes, ...												
Wafer Seals, ...												
Sand, Europe, ...												
Pounce, ...												
Paste Boards, ...												
Camel hair Pencils, ...												
Crimson Lake, ...												
Prussian Blue, ...												
Gamboge, ...												
Burnt Sienna, ...												
Indian Ink, ...												
Books, Genl. Letter, &c,												

(Signed) ————————————

Executive Engineer,

Division Ganges Canal.

APPENDIX H.

Authoritative decisions on certain points submitted by Executive Officers.

QUESTION. *Lieut. Strachey's letter No. 53 of 20th June, 1843. Enquires how he is to obtain the cost of packing cases sent with stores from magazines, how it is to be debited, and what is to be done with the articles themselves? Also, in case he is directed to sell them, how the amount should be charged in his accounts?*—ANSWER. Secretary Military Board's letter No. 1939, of 22nd July, 1843, states, "that it would probably be the best plan to sell the packing cases in question, if they are not required in the department, and Lieut. Strachey might indemnify himself for any loss in the sale by submitting a bill for the difference, and the proceeds might be brought forward in the periodical account current." "Lieut. Strachey can be furnished from the Board's office with the rates of any articles supplied to him from the Ordnance Department, whenever applied for."

The plan generally adopted is to return to the magazine all the packing cases, &c. received, and to submit a bill for their value, supported by the Magazine Officer's receipt.

QUESTION. *Lieut. Strachey's letter No. 49 of 30th May, 1843. Understands that Major Cautley had proposed to Government, the employment of public cattle on the Ganges Canal works, for the conveyance of materials; such a measure being undoubtedly a great saving, requests that he may be informed of the decision of Government on the subject,*—ANSWER. Commissary General's letter No. 1173, dated 9th June, 1843, protests against the proposed measure as being most inexpedient at any time. "We have no carts to give, but if our Elephants and Camels are so employed, there would be few or none amongst them, with sound backs in the course of a month."

"The objection applies to a particular employment, and holds good not only now, but at all times."

The above view was concurred in by the Hon'ble the Lieutenant Governor, N. W. P. Vide Secretary's letter No. 3706 of 15th August, 1843.

QUESTION. *Major Baker's letter No. 389 of 1st April, 1845, enquires 1st, "whether in the prosecution of public works it be necessary that the undermentioned documents should be engrossed on stamped paper, vizt. contracts or agreements for excavation of*

earth, manufacture of brick, or supply of materials, and security bonds for the repayment of Government money advanced on the above account; 2ndly, whether in the event of the documents above mentioned being engrossed on other than stamped paper of the prescribed value, the Executive Engineer can, in a Civil Court, enforce the fulfilment of a contract, or recover the amount of security, when justly forfeited; or, in other words, 3rdly, whether the general exemption appended to Regulation X. of 1829 *be intended to apply to the Department Public Works?*—ANSWER. The Secretary to the Government N. W. P. in his letter No. 2166 of 1845, dated 23rd May, 1845, to the Military Board states in reply "that the exemption which follows article 12, Schedule A. Regulation X. of 1829 (as copied in the margin*) is in his Honor's opinion entirely applicable to the documents mentioned by Captain Baker. His Honor therefore conceives that there is no necessity for executing such documents on stamped paper.

* Bonds given to or by the officers of Government on account of any matter or thing of or belonging to the Government in its political or territorial capacity.

QUESTION. *The Superintendent of Canals, having granted to Commissioned Officers, in the Canal department, temporary leave of absence on private affairs,*—ANSWER. The Board, in their Secretary's letter, No. 3565 of 7th September, 1847, ruled "that the only pleas, under which a Superintending Engineer can, under existing orders, grant leave, are first on Medical certificate, and in such case the party should furnish the requisite certificate, and secondly, on urgent private affairs, in which case the Superintending Engineer must satisfy himself of the validity of the plea before granting it.

QUESTION. *Major Baker's letter No.* 1472 *of* 10*th April,* 1847, *enquires the power vested in him to grant leave of absence to uncovenanted subordinates in the Canal department,*—ANSWER. Secretary Military Board's letter No. 1600, dated 25th June, 1847, transmits copy of a letter No. 2448 of 10th idem, with annexures from Mr. Secretary Thornton, "communicating the power vested in you by Government to grant leave of absence not exceeding one month in each year, over and above the occasional holidays, whenever you are of opinion that the indulgence can be granted without detriment to the public service, and is merited by the good conduct of the applicant."

QUESTION. *Lieut. Strachey's letter No.* 105, *dated* 24*th October,* 1845, *asks for permission to advance to Asst. Overseer Sergt. Johnstone the sum of* 200 *rupees to assist him in building himself a bungalow at Roorkhee,*—ANSWER. The Secretary Military Board's letter

No. 6223 of the 16th December, 1845, states, "that an advance of 200 rupees requested by Sergeant Johnstone, to enable him to build a house at Roorkhee, is quite inadmissible."

QUESTION. *Lieut. Smith's office and private carriage having been seized for military purposes and a complaint made,*—ANSWER. The Hon'ble the Lieutenant Governor replied, in Mr. Secretary Thornton's letter, No. 4853 of 11th November, 1846, that "when absolutely required for the march of Troops, the seizure of carriage is authorized by Regulation XI. of 1806, Section 3."

QUESTION. *Lieut. Turnbull's letter No. 225, dated 10th June, 1847, requests that sanction may be obtained, for placing the whole of his Bricks under charge of the Civil village powers, as he is anxious to remove his establishment,*—ANSWER. The Commissioner of Meerut, in reply (No. 257 of 14th June, 1847,) states that he has directed the Collectors of Meerut, Mozuffurnuggur and Saharunpoor, "to provide for the protection of the bricks by making the Zumindars of the villages where they are collected, responsible for their safe custody. The village Chokidars ought likewise to be ordered to look after the heaps, and see that they be not pilfered by the inhabitants of the neighbourhood."

QUESTION. *Reference having been made regarding a statement of conditions of service of Bildars &c. employed on the Ganges Canal Works,*—ANSWER. The Hon'ble the Lieutenant Governor decided (in Mr. Secretary Thornton's letter No. 617 A. of 1847), dated 29th September, 1847, that he could "only refer you to Sections 5 and 6 Regulation VII. of 1819, and to the constructions of the Nizamut Adawlut noted in the margin,* which have reference to that enactment. By the two first, you will see that European British subjects are held not to be liable for prosecution as defendants under the Regulation in question, though they may sue as complainants; and by the last you will perceive that there must be either a stipulated term of service, or a contract for specific work, to render artizans and other workmen liable under Section 5, of the Regulation."

* No. 340 dated May 25th, 1821.
345 dated July 20th, 1821.
381 dated April 29th, 1823.
1329 dated May 27th, 1842.

"The Lieutenant Governor does not consider that there would be any difficulty in your having a simple form of agreement drawn up and lithographed, to which every laborer employed on the Canal should be required to subscribe. In this contract the forfeiture of arrears for a certain period might be made the stipulated penalty of absconding without due notice. The conditions of such an engagement would necessarily become in a short time generally known."

In accordance with the above suggestion, an agreement paper has been drawn up and adopted in the northern division, a copy of which is hereto annexed.

Copies of the sections and constructions above referred to are also attached.

FORM OF AGREEMENT PAPER.

هم که سب ٹنڈیل اور بیلدار نوکر علاقہ نہرگنگ ضلع اوتر کے هیں

جو هم سب بیلدار نوکر نہرگنگ ضلع اوتر کے هیں اسواسطے اقرار کرتے هیں اور لکھدیتے هیں که هم لوگ همیشه موافق دستور نوکروں کے وقت ضرورت آئینگے اگر نوکري چھوڑنا چاهیں تو پندرہ دن پہلے خبر چھوڑنے نوکري مذکور کي بحضور صاحب بہادر مہتمم نہرگنگ کے کریں اور جوکوئي هم میں سے بسبب سستي کام یا شرارت اپني کے کار سرکار چھوڑکر بیٹھه رهے یا بدون پندرہ دن پہلے خبر دینے کے نوکري چھوڑکر کہیں چلا جاوے تو تنخواہ چڑهي هوئي اُسکي دو مہینے تلک کي سرکار میں ضبط هوجاوے اور اگر بابت اُس تنخواہ کي وہ شخص پھر کبھي دعوی کرے تو جھوٹا هو اور جو واجبي حصه کام طرف صاحب بہادر مہتمم نہرگنگ سے مقرر هوجاوے وہ کام هم پوراکردیں یہه شرط نوکري اور ٹھیکه کام هماري کي هی اسواسطے یہه چند کلمه بطریق اقرار نامه کے لکھدئیے که سند هووین اوروقت حاجت کے کام آویں * تحریربتاریخ

Sections 5 *and* 6 *of Regulation* VII. *of* 1819.

V.—All persons who may voluntarily engage to serve as workmen of any description for a stipulated term, or who may voluntarily contract for the performance of any specific work, and who without good and sufficient cause shall wilfully quit the service so engaged for, before the expiration of the term agreed upon, or shall wilfully neglect to perform the work so contracted for, shall be deemed guilty of a misdemeanour; and on conviction, before a Magistrate or Joint Magistrate, shall be liable to a sentence of imprisonment, not exceeding one month. The Magistrate or Joint Magistrate may likewise require the persons so convicted to complete their stipulated term of service, or to perform the work contracted for if it appear just and proper to require the same; and any subse-

4 lb 12½ oz

هم که سب ٹنڈیل اور بیلدار نوکر علاقه نہرگنگ ضلع اوتر کي هین

جو هم سب بیلدار نوکر نہرگنگ ضلع اوتر کي هین اسواسطي اقرار کرتي هین اور لکھدیتي هین که هم لوگ همیشه موافق دستور نوکرون کي وقت ضرورت آئینگي اگر نوکري چھوڑنا چاهین تو پندرہ دن پہلي خبر چھوڑني نوکري مذکور کي بحضور صاحب بہادر مہتمم نہرگنگ کي کرین اور جوکوئي هم مین سي بسبب سستي کام یا شرارت اپني کي کار سرکار چھوڑکر بیٹھه رهي یا بدون پندرہ دن پہلي خبر دیني کي نوکري چھوڑکر کہین چلاجاوي تو تنخواہ چڑهي هوئي اُسکي دو مہیني تلک کي سرکار مین ضبط هرجاوي اور اگر بابت اُس تنخواہ کی وہ شخص پھر کبھي دعوی کرے تو جھوٹا هو اور جو واجبي حصه کام طرف صاحب بہادر مہتمم نہرگنگ سي مقرر هوجاوي وہ کام هم پوراکردین یہه شرط نوکري اور ٹھیکه کام هماري کي هی اسواسطي یہه چند کلمه بطریق اقرار نامه کي لکھدئیي که سند هووین اوروقت حاجت کي کام آوین * تحریربتاریخ

quent conviction of wilful neglect to comply with such requisition shall be punishable by a further sentence of imprisonment, not exceeding two months.

VI.—Clause First.—The provisions of the foregoing Section are also declared applicable to domestic servants, who may engage to serve for any fixed term, or during the performance of any specific service, or though no such engagements have been entered into, may be employed from month to month, and without good and sufficient cause, shall wilfully quit the service of their employer before the expiration of the fixed term, or before the completion of the stipulated service, or with respect to monthly servants, without giving previous notice for a period not less than fifteen days.

Second.—In like manner, no master, or other person, employing a servant for a fixed term, or for a specific service, or from month to month, shall be at liberty without good and sufficient cause, to discharge such servant against his will before the expiration of the fixed term, or the completion of the specified service; or, with respect to servants employed from month to month, without giving previous warning of the intended discharge for a period of at least fifteen days, or paying his wages for that period.

Third.—It shall be the duty of the Magistrate or Joint Magistrate, on application made to him upon the stamp paper prescribed in Section 18, of Regulation I. 1814, (vizt. bearing a stamp of eight annas) to enforce the provisions of the above clause, by causing payment to any servant who may be discharged in opposition thereto, of a sum equal to half a month's wages, in addition to any arrear of wages which may be due to him at the time of his discharge, or if the servant have been engaged for a fixed term, or for a specific service, by causing payment to be made to him of such sum as may appear fully adequate to any loss sustained by him from being discharged before the time agreed upon.

Fourth.—Provided, however, that no servant shall be entitled to recover more than his arrear of wages when he may be discharged for misconduct proved to the satisfaction of the Magistrate or Joint Magistrate, and appearing sufficient to warrant his discharge, nor shall any workman or servant, be liable to punishment under the provisions of this Regulation, when it may be proved, to the satisfaction of the Magistrate or Joint Magistrate, that his quitting the service of his employer, without previous notice or before the expiration of a stipulated term or without having completed the performance of any work contracted for, was occasioned by gross mal-treatment, or by non-pay-

ment of wages due, or by any other cause which may appear to the Magistrate or Joint Magistrate, sufficient to justify or excuse the act complained of.

VII.—The whole of the sentences which may be passed by a Magistrate or Joint Magistrate under any part of this Regulation will of course, be open to the regular control of the Court of Circuit of the division, according to the general rules in force on this subject.

CONSTRUCTIONS OF THE NIZAMUT ADAWLUT.

To the Bareilly Court of Circuit,

Dated the 25th May, 1821.

I am directed by the Court of Nizamut Adawlut to acknowledge the receipt of a letter from you, dated 11th instant.

No. 340, 1819, Reg. VII., Sec. 6, Cl. 3.

2nd.—In reply, I am directed to communicate to you the opinion of the Court, that the Rule contained in Clause 3, Section 6, Regulation VII. 1819, cannot be considered applicable to European British subjects, and that consequently, under the general Regulations, an award by a Magistrate, (even though a Justice of the Peace) of the nature alluded to in the latter part of the first paragraph of your letter, is unauthorized and illegal.

3rd.—You are of course at liberty to consult the Advocate General, as to how far he may consider such a decision legal under the Act of Parliament, to interpret which does not fall within the province of this Court.

4th.—It is at the same time obvious to remark, that from a conviction of a British subject by a Magistrate, in his capacity of Justice of the Peace, under 53rd George III., Cap. 155,* *the appeal is not to a Court of Circuit, but to the Supreme Court in Calcutta.*

To the Bareilly Court of Circuit.

Dated the 20th July, 1821.

I am directed by the Court of Nizamut Adawlut to acknowledge the receipt of a letter from you under date the 2nd instant, together with its enclosure from the Magistrate of Zillah Moradabad, dated the 27th ultimo.

No. 345, 1819, Reg. VII. Sec. 6.

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* This is superseded by a Regulation which vests the Appellate power in the Sessions Court.

2nd.—The rule contained in Clause 3, Section 6, Reg. VII. of 1819, being clearly not applicable to European British subjects as defendants, and it appearing from Mr. Halhed's letter to your Court, that he is in possession of a copy of my letter to your address, bearing date the 25th May last, the Court are not aware of the necessity of any further orders on the subject of Mr. Halhed's enclosure in your letter above acknowledged. With respect to the query occurring in the second and at the conclusion of the third paragraph of Mr. Halhed's letter, it is obvious, that Clause 4, Section 16, of the above cited Regulation, cannot be acted upon at all against such masters or persons, as may not be liable to the Regulation and subject to the Magistrate's authority; at the same time, that against such servants as are liable and subject, the Regulation may be acted upon, even in favor of those very masters who are exempted from being made defendants.

To the Acting Magistrate of Zillah Sylhet,

Dated the 29th April, 1825.

The Court of Nizamut Adawlut have had before them your letter, under date the 16th instant; requesting to be informed whether the second punishment directed by Section 5, Regulation VII. 1819, in cases of workmen neglecting to finish their work, should be considered final and conclusive, or whether the Magistrate is at liberty to repeat such punishment until the work is performed.

No. 384, 1819, Reg. VII. Sec. 5.

2nd.—In reply, I am desired to communicate to you the opinion of the Court, that the sentence of two months' imprisonment, prescribed in the Section above quoted, is intended as punishment for wilful neglect to perform work undertaken, and not as a means of compelling the performance of it; consequently, that the Magistrates are not competent to repeat the punishment of two months' imprisonment or to take any further measures towards compelling an actual performance of the work engaged for.

The following Queries were submitted by the Magistrate of the 24-Pergunnahs, to which the replies in juxtaposition were given:—

No. 1329, 1819, Reg. VII. Sec. 5 and 6.

Questions. 1*st.*—*Can workmen, such as Mistrees, Moochees, or other Artizans, be brought within the meaning of the enactment*

quoted, supposing that they have taken advances from their employers and agreed to work for the same, without any stipulation as to the precise term or specification of the job that they are to perform?

2nd.—By what Magistrate are cases, under the above mentioned provisions, cognizable: the Magistrate of the district wherein the agreement was entered into, or that of the district wherein the delinquents reside, or to which they may have decamped?

Answers. 1st.—There must be a stipulated term of service, or a contract for the performance of specific work, to render Section 5, Regulation VII. 1819, applicable to the cases alluded to.

2nd.—Such cases may be prosecuted either in the district in which the agreement was executed, or in that in which the defendant resides.

Calcutta Court, 18th March: Western Court, 27th May, 1842.

APPENDIX
E

Ganges Canal Appendix
Sig I Vol III

Report on the State of the Ganges Canal Works, at about the period when their General direction was transferred from Major W. E. Baker to Major P. T. Cautley.

Camp. Gurhmooktesur 11th January 1848.

The space occupied by the Myapoor Dam and the Escape Channel in rear of it was once excavated to the proper depth - but has since received considerable deposits of Gravel and Sand - From the space in front of the Dam and Regulating Bridge - a vast quantity of soil has been removed - but the lower 4 or 5 feet of excavation not having been completed before the rains of 1845, has been purposely left under the impression that if this space were now excavated, it would soon be refilled with silt similarly to that in rear of the Dam. The cause of this deposit appears to be the sudden change from the rapid fall above the Dam - to the diminished slope below it. It is probable that some inconvenience will always attend this unavoidable disposition of the fall, but it will doubtless be felt in a far less degree than at present when the projected uniform slope from the Pyree that to the Dam shall be carried out. The excavation is completed at the site of the Regulating Bridge, and the portion of Canal Channel in rear of that work, left by Lieutenant Strachey, is now being cleared

out. The Bochna nulla has been deepened to suit the level of the works.

2. The foundations and floor of the Mysapoor Dam have been completed, and a portion of the East and west Abutments has also been built.

The Piers of the Dam and the attached sluice work are purposely deferred until near the period when they are likely to be required to retain the Canal supply. The deviations from the original designs for this work are as follows.

Cross foundations, connecting the front and rear curtain walls have been added under every 4th. Pier - and the floor has been made of stone instead Brick on edge - with reference to the heavy boulders which will be annually washed over it during floods. The edges of the floor are made with Chisel dressed stone - the remainder is formed of smooth surfaces of broken boulders carefully fitted together and grouted in.

The Mysapoor Regulating Bridge has been founded, the floor and Piers built, the Arches turned and the Spandril Walls completed to level of crown of the extrados of the Arches. The deviations from the original designs for this work are as follows. The foundations of the piers have been carried down to the same depth as those of the front and rear curtain walls. The length of the Piers has been increased 8 feet, the cutwaters both up and down stream having been built beyond the floor instead of on it. A stone floor similar to that of the Dam had been substituted

substituted for the Brick counter Arches as proposed, and the cutwaters of the piers have been built of dressed Stone. The reason for increasing the length of the piers is to allow more room for stowing the sluice planks or sleepers that will be employed to close the bays. The weight and number of these being so great as to preclude the possibility of their being frequently removed to a Store Room. It is proposed that sluice Gates should be used instead of sleepers for closing the Waterways - that they should be from 2' to 3' in depth and of varying thickness to resist the pressure at different depths - and that they should be worked by Cast Iron Crab Capstans fixed on the piers. The increased length of the piers will admit of this arrangement being adopted, without curtailing the intended width of the Roadway. The Chat steps on both the Up Stream Flanks of this Bridge are completed very nearly as designed. The Bachna Inlet is completed - but with considerable deviations from the design. The width of Waterway was reduced from 50 to 20 feet, the latter dimension having been considered sufficient after further acquaintance with this little Torrent. The Overfall was at first built by Lieutenant Strachey as a perpendicular drop - semicircular in plan - but it was found that the floor though faced with the largest Stones procurable was unable to withstand the impact of boulders &c. falling vertically 30 feet - and the form of the Overfall

was subsequently converted into an Ogee by Lieutenant Yule.

The Bochna Bridge is completed as designed. The masonry Revetments connecting the Bochna Inlet, the Regulating Bridge and the Dam are completed to their full height and are now being plastered. The Bythuk wall is completed on the same design on which it was begun in Major Cautley's time but will perhaps require some modification to suit the Ghat steps. The Ghat, including the Revetment; the descent from the Upper to the lower Terrace, and the long line of steps for bathing is completed - except that the last mentioned steps are not yet faced with dressed stone - for which funds were wanting. The Tukeri Revetment is completed in two portions with a terrace between - at the level of the lower terrace of the Ghat - This arrangement was adopted to save masonry, as the mean thickness of the Wall must have been much increased, had not the height been divided into two portions.

The 1st class Sluice at Nyapoor is completed with no material difference from the design.

3. The Lounda Cana Walla Inlet is left for the present. The Kunkhul drainage Inlet enumerated in the printed Report among the works of the Northern Division but not included in the Estimate has been built, but as it is not desirable at present that the waters discharged by it should be delivered into the Canal, they are conducted across the channel between

Embankments

Embankments, as a temporary Arrangement.
A Bridge on the old road between the Towns of
Kunkhul and Jowallapoor near the Ramicoow,
has been conceded by Government. North Western
Provinces to the inhabitants of those Towns and is
now in course of construction. The Bridge will
be built of 3 arches according to the general de-
sign, except that Curtain walls and a floor
will be added to the foundations which rest on
compact boulders and gravel and that the Abut-
ments will be considerably strengthened. These
foundations and the massive parts of the Abut-
ments will be built of boulders (which abound
on the spot) and of pukka cement. The founda-
tions of this work are now in progress. The site
of the Jowallapoor Bridge has been shifted from
opposite the old Tuhseel to a spot preferred by
the inhabitants about ¼ of a mile lower down.
The state of progress of this work is much the
same as that of the Kunkhul Bridge, which
it will resemble in every respect. The Boulders
for its construction are not found on the spot,
but have been brought from a short distance.
The foundations will rest on good clay. The con-
struction of the Ramipoor Dam is in progress. The
excavations are almost if not quite completed, and
materials for building are collected. The boulders
for the massive parts of the foundations have
been brought 3 or 4 miles. To obviate the dif-
ficulty of obtaining water for this work, aswell
as for the Bridges of Kunkhul and Jowallapoor

(the Springs throughout this tract of country being very deep and scanty) arrangements have been made to bring a small stream down the Canal.

A has been excavated for this along the centre of the Channel and Galleries (supported by sheet planking) have been driven under the bars left for the communications of the country across the Canal.

4. The excavation of the Canal Channel between Myapoor and the Ramipoor Rao was completed before Major Cautley relinquished the direction of the works - but the banks and slopes, which had cut into deep ravines, have been repaired and grassed, and an arrangement has been adopted whereby I hope that the lower slopes will be protected from further material injury, until the Canal is opened - when of course it must be superseded by some other device. The drainage of the surface a.b. may be without great difficulty thrown to the rear-but that of b.c.d.e. must either be absorbed or must find its way to the bottom of the Canal.

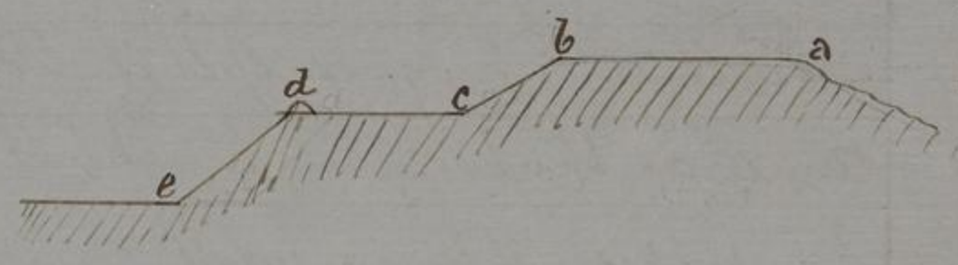


Fig 6
B. 52

The absorbing process will only be effectual during light rain, and the means used to assist it. Viz: making a slight edging at d. has frequently the effect of holding up a body of water, sufficient when it does find vent to cut out a large ravine. The method adopted, and which certainly answered well during the last rainy season was to form

Open

open spouts or channels of Masonry down the slopes &c. at the lowest points, and to conduct to these points, the drainage of the surface — b. c. d. by means of a small drain excavated at c. The Masonry spouts are made of inferior materials and with slight dimensions, as they are not intended to be permanent.—

5. Between the Ramipoor Rao and Peeranhulleeur, nothing has been done beyond a fresh reconnoissance of the line, with a view to avoiding the deep digging at b. Thur. I have satisfied myself that this may be effected by dividing the double falls of Chinnoori into two, but I have not yet the data for calculating what would be the difference of cost of the respective lines.

6. Though the Rutmoo Dam is not yet commenced, I have considered carefully how it might be possible to prevent the Dam from throwing a large sheet of back water up the valley of that River. The only method which has suggested itself to me is that of a double Dam—(one in the alligniment of each bank) connected by a small Tunnel under the bottom of the Canal. During floods both Dams would be thrown open, and the Tunnel would be closed to prevent its being choked or blown up. At ordinary times, the Dams being planked up would retain the Canal supply—and the tunnel would carry off the leakage through the upper Dam, and the natural stream of the Rutmoo.—

7. The deep digging of Peeran Kulleem is only partially commenced at the South end as it has been determined to convey the excavated Earth by a Rail to form the Solani Embankments. and the necessary Iron work has not yet been received from Calcutta, though daily expected. The line of Canal has however been partly laid down and is being extended to the Rutmoo; in the Valley of which there will be excavation and Embankments on which to employ Surplus laborers, until the Rail shall be formed.

8. In connection with the Peeran Kulleem digging. I would record a suggestion, which may possibly be of use hereafter,- In forming the Solani Embankments it is certainly advisable that each successive layer of earth should be abundantly watered - In the part already formed this object had been effected (at a considerable expense) by means of Pumps and a fire Engine working in Pukka Wells. But as the level of water in the Rutmoo is higher than that of the Canal bottom in the Valley of the Solani it may be found practicable to lead water from the former River in pipes or in an open channel, through the Peeran Kulleem Hill to the Solani Embankments. I have not worked out the details of this scheme nor estimated its cost - but I have little doubt that it would be found both more efficient and more economical than the present System.

9. The Eastern portion of the Solani Aqueduct

had

has been commenced. The soil in the Valley of the Solani East of the River, having been found on Examination to be of good quality to a depth of from 2 to 4 feet below the surface it was determined to obtain Earth from side cuttings, and to dispose it in an uniform stratum about 2 feet thick. over the proposed bottom of the Canal (150 feet wide). Each layer of earth of 6" thick was well watered and rammed. To this work was afterwards added from extra excavations a raised mound, 20 feet wide at top, along the centre of the Canal. Its upper level is that of the Canal bottom at the East side of the Valley, but it has a slope to the South west of 1 in 1200. This mound is intended for the reception of the Rails. which, when once placed will not require to be shifted, until the whole channel and Embankments are raised to their level i.e. until nearly 3/4ths of the work is completed. The Earthwork above described has been consolidated by the Rains of one season and has stood remarkably well.

10. The Mukerain Brick fields (to be more particularly mentioned hereafter) are intended to supply Bricks for the Aqueduct and Masonry Revetments on both sides of the Canal: but the kilns being on the Right or West Bank. the Bricks for the East Revetment must necessarily cross the Earthen mound and the Railway. This contingency has been provided for by means of a Tunnel under the mound. of height sufficient

to admit of the passage of a loaded Cart, the
sill being at the same time so high as to prevent
the passage of drainage water from the upper
to the lower side of the Aqueduct. As this structure
is intended for a temporary purpose only - it has
been built of inferior materials but of such di-
mensions as will in my opinion ensure its
stability for 6 or 7 years.

11. The Iron work of the Rails having been
expected to arrive soon after the rainy season
a considerable body of laborers, who might
otherwise have been dispensed with, were re-
tained with a view to their employment in
setting up and making the Rails, but when
the expected Iron work did not arrive, it be-
came necessary to provide other employment
for the working parties and in the absence of
more profitable work, a portion of them were
set to dig the more sandy strata of the side
cuttings and to throw it up on the line of Em-
bankments outside the masonry Revetments -
I would certainly have preferred that these
embankments should consist entirely of tenacious
soil - but I hope and believe that a small
quantity of sandy earth, enclosed in an im-
mense mass of good clay, and separated
from the canal water by a double line of
Masonry Revetment will not injuriously af-
fect the stability of the work - had the
laborers not been so employed - they must have
been

been discharged and much further delay must have been incurred in collecting them again after the arrival of the Iron work.

12. I have omitted to notice one piece of Earthwork connected with the Earthen Aqueduct. Before entering on the Valley of the Solani, the line of Canal crosses a Ravine or natural line of drainage flowing from North West to South East. It is intended that this drainage should not cross the Canal, but that it should be directed into the Solani above the Aqueduct, and this object has been effected by throwing a Bund across the Ravine in the line of the Right embankment of the Canal so as to form a pond. And to prevent the water ever topping the Bund in heavy Rain an Escape Channel has been provided whose sill is 3 feet below the top of the Bund. This pond was of some assistance in the Brick field, and as it is undergoing improvement by the present operations will be more useful hereafter.

13. It is calculated that the number of earth waggons required to complete the Channel and Embankments of the Aqueduct in 4 or 5 years is 200. for 100 of which the Iron work had been prepared in Calcutta under the orders of the Military Board. It is supposed that the remainder can be obtained more economically from England. The Rail itself is to consist of flat bar Iron (a quantity of which is also on its way from Calcutta) laid flat on

Longitudinal wooden bearings connected at short intervals by cross sleepers - which will also act as chairs - The only Iron bars procurable being of various thicknesses - the level will be adjusted by cutting away more or less of the longitudinal sleepers. -

14. The forms to be adopted for Earth waggons has received the most careful consideration - The arguments for and against — Tilting Carts may be thus stated - Tilting Carts would require little labor in unloading and by a well arranged system of diverging branch Rails might be made to convey the Earth so near to the requisite position, as to admit of its being spread with the forma.

On the other hand the double frame and extra iron work of a tilting Cart would greatly increase the weight of draught and the cost of construction. 2nd The diverging branch Rails necessary to give effect to the Tilting Carts would require to be frequently shifted, and relaid on different levels and in different positions, a process which, with inexperienced workpeople, and Rails of different thicknesses, would be troublesome, tedious and expensive. - 3rd The quantity of rail requisite would be more than doubled. -

Considering the balance of the arguments to be against the use of tilting Carts, I propose the following plan, as best suited to our means, and to the comparative cheapness of human labor in India - Two Central

lines

lines of rail (for the going and returning waggons) will be laid down on the mound above described, and will probably not require shifting for two or three years. The cards will be of the simplest construction mere boxes in fact firmly framed and fixed to the Iron Axles. Their sides will open with a hinge to facilitate the unloading and the lead forming the side, will fall over and cover the rail. so as to prevent the earth from falling upon it and clogging it up. The soil will be conveyed in baskets to the required position. The wood work of 50 cards such as are above described is now nearly ready.

15. Some Godowns and a Smith's shop will be established at Mahewar (on the East bank of the Solani Valley) for the protection of stores, fitting and repairing Iron work &c. &c.

16. The Masonry work of the Solani Aqueduct was commenced in May 1844. but the rate of progress had been throughout and still continued limited by the supply of Bricks. Up to the present time the foundations of 6 piers have been sunk down to their full depth. two more piers are in course of sinking. both Abutments with their flanks or long walls are laid down and are being built preparatory to sinking.

17. The foundation Blocks of the Piers

are 22' long, 20' wide and 20' deep - and the spaces between them are exactly equalized.

The plan and disposition of the Abutment Blocks has been modified - an addition of 6 feet has been made to the width of the Abutment itself - and a corresponding reduction in the Flank - the area of the whole foundation remaining nearly the same - A line of curtain blocks along the front and rear of the floor of the Aqueduct, and connected with the piers by cross blocks - under the cutwaters, has, under my recommendation been sanctioned by Government, and 11 of these additional blocks are built, but two only are yet sunk down to their full depth of 20 feet. -

13. The curb frames or Neemchuks of the large blocks are each made with 12 Sawn Timbers of the usual scantling disposed in this manner - In the Frames first made, each crossing of the Timbers, was secured with an Iron screw bolt and nut, but for these we have since substituted trenails except at the 4 external angles. In the frames first prepared the bottoms were not made flush - as it was supposed that the timbers would be needlessly weakened by being halved into each other - The frame therefore rested on two of its opposite sides, the other two remaining hollow - no particular rule

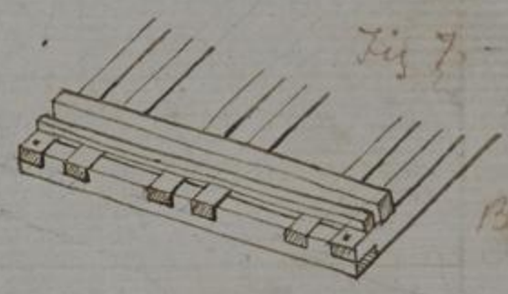


Fig 7.

B. 52

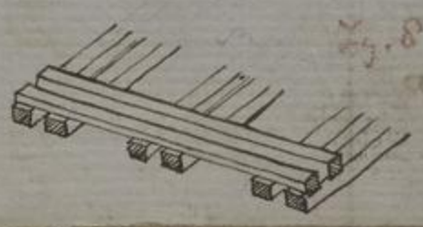


Fig. 8

B. 52

rule was observed in laying these frames. and it so happened that those in the line of the first pier, were placed with the hollow side out, and the flush sides next to each other; but when the undersinking commenced the inconvenience of this arrangement became apparent. The flush sides being deeper in the soil disfronted the block, while the sand constantly flowed in through the hollows and greatly impeded the progress of sinking. In the next pier, the disposition of the frames was altered, - the flush sides being placed outside and the hollows next to each other. and a marked difference in the rate of progress was immediately perceptible: so great indeed is this difference that I believe the sinking of the 1st pier has cost more than double that of any other.

We have subsequently tried flush frames, without any apparent mischief arising from weakening the timbers. the external pieces only are, however, halved into each other. -

19. In all the foundation Blocks courses of hoop-iron are laid between the courses of brick work and crossing each other at every alternate foot up to the height of 10' from the curb frame. -

20. In consequence of the strength of the curb framed and the use of hoop-iron, the occurrence of cracks in the masonry during the progress of sinking has been very rare - and confined to one or two blocks which had been

disturbed by floods breaking through the Coffer Dam.-

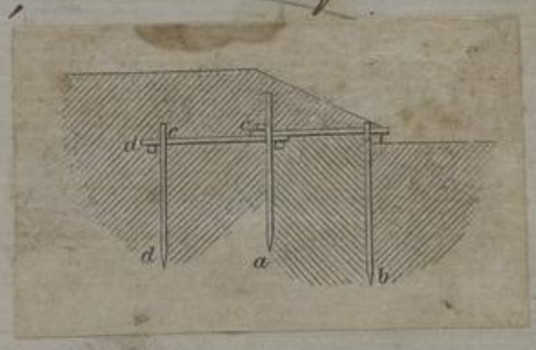
21. The underdinking has been effected almost exclusively with simple machinery worked by common laborers and without the aid of divers.- The Jhann or tool used for excavation will be understood from the annexed sketch - it is raised by means of a simple Windlass worked with fixed Spokes.

The saving effected by this method as compared with that practised by divers is very considerable and the progress is certainly not less rapid. For a work of this extent it would indeed have been difficult - if not impossible, to procure professional well diviers in sufficient numbers.

22. The soil hitherto passed through by the Blocks has been sand, sometimes fine - sometimes largely mixed with clay. The finer the sand the more rapid has been the progress. but no difficulty beyond delay has been experienced in any soil.-

23. There was necessarily a good deal of preliminary excavation and other work connected with the Aqueduct of which few traces now remain. The first foundations laid were those on the Right Bank of the Solani under which the principal current then flowed. A space was therefore enclosed in a Coffer Dam. and two new channels were dug, to give the flood a central bed in the bed of the River.-

24. The Coffer Dam consisted of two parallel rows of 12' and 15' kunnies - driven close, and framed together, the whole being further supported by heavy ties c.c. at short intervals attached to piles d. d. in the rear. The current of the first floods set longitudinally through the space between a and b, but was checked by cross rows of bullies - the sand washed out - being replaced by similar soil enclosed in mat bags. In spite of all precautions, however, the floods broke frequently into and over the Coffer Dam and considerably impeded the work. One of the new channels so was completely obliterated, but the final effect of the combined measures has been to set the Solani completely over to its left bank - which it has cut away to a considerable extent. -



25. The River wall of the Coffer Dam during the last rainy season. Consisted of one of the Aqueduct pier foundations, sunk to its full depth, and surmounted by cribs filled with masses of vitrified brick and backed by a sand bund. It is in rear of the old Coffer Dam (the piles of which have been extracted) by the width of half a bay. These precautions effectually excluded the floods of the last year which however, were light. —

26. The Coffer Dam last described, has not been dismantled, the work within it, remaining as it was when done, can more conveniently be

executed during the ensuing rainy Season-
and in the mean time, as much work will be
Commenced outside the Coffer dam as there is
reasonable hope of completing before the 15th
of June.-

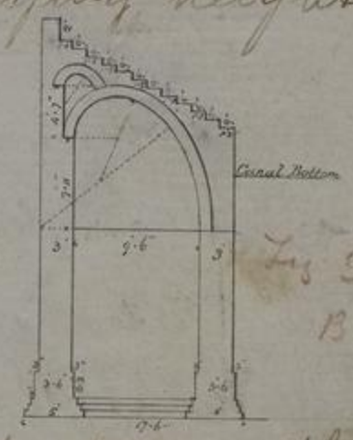
27. It may here be remarked that the
length of the Masonry Aqueduct is less than
the breadth of the River, on the line laid
down for the Canal. and it will, therefore, be
necessary on both sides to give deep foundations
so that part of the Masonry Revetment which
will be built in the present bed of the River-
I would propose that the upstream wall
should be founded on Blocks and the rest on
piles-

28. The direction of the Central line of the
Masonry Aqueduct had been determined before
my Connection with the Ganges Canal- and was
necessarily rather oblique to the Solani at that
part of its Course. It remained for me, however,
to fix the exact position of the work on the
Selected line- and this was done with such
reference to the windings of the River as would
admit of the stream being brought down per-
pendicular to the Aqueduct by a straight cut
from one to two miles in length-

29. It merely remains to allude to the dis-
cussions which have arisen regarding the thick-
ness of Abutments of the Masonry Aqueduct.- Lt
Lieutenant Colonel Abbott R.E. when referred to
by the Governor General expressed an opinion
that the Abutments

too weak, and that they should have at least 18 feet of thickness with counterforts. Mr. F. W. Simms who was subsequently consulted, recommends 23 feet thickness with counterforts. The foundations provided by me, before this question was mooted will admit of 21 feet thickness of Abutments. Counterforts if necessary may be added, but I would recommend that they be founded on piles driven in the direction of the thrust. It appears to me, however, that neither Colonel Abbott nor Mr. Simms have properly taken into account the small height of the piers.

30. The masonry Revetments have been commenced west of the Solani, and have made considerable progress. Each Revetment consists of a double wall supporting a flight of steps. The exterior width of these walls is 15½ feet, and there is a clear space of 150 feet between them. The upper surface of the Revetment will be a flight of steps as in the original design, but the method of supporting them on two circular arches has not been followed partly with a view of saving the labor involved in so much arch work and partly because the proposed method would not easily admit of modification to suit varying heights of Revetment. The section adopted consists of two perpendicular walls connected by an arch springing from unequal heights like that of a flying Buttress. The long walls are connected with each other at the



bottoms, but they have a wide footing, and cross walls are built between them at distances of 15 feet apart.-

31. The material used in the Revetments is not all of such good quality as that selected for the Aqueduct. For the cross walls and for the inner faces of the long walls, some second class bricks have been used. the exposed surfaced, Arches and steps being made of the best bricks. Masses of Vitrified Brick or Jhansi are also extensively used in the Construction of the long walls a bond of brickwork being interposed between every 3 feet in height of Jhansi work.-

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Appendix

32. The Model Room. the building of which was completed before I assumed charge of the Ganges Canal, is now being furnished with Tables, Shelves and Glass Cases to receive the Books and Philosophical Instruments granted to Major Cautley by the Honble Court of Directors.-

33. The workshops and Godowns have been extended all round the interior of the Square provided for that purpose in rear of the Model Room. but still do not afford sufficient accommodation. They are occupied almost exclusively by Smiths forges. The Carpenters having been removed from their allotted quarter, now work in sheds erected both within and without the workshop Yard.-

34. The possession of an efficient workshop has enabled us, not only to prepare the implements

implements absolutely necessary for carrying on the works, but to introduce many improved means not usually met with in the public works in India - at least in these provinces, amongst these may be enumerated the whole of the machinery requisite for underbinking the foundation blocks - Pumps which are extensively used not only for Watering the Earthwork, but for supplying water to masons &c" - Wheelbarrows and hand carts - which, on the excavation, on the masonry works, and in the Brick fields, have in a great measure superseded the use of Baskets - Weighing machines, for weighing the loads of fine wood, Aspla &c" brought in for the Kilns - Framed Centres for the Revetment Arches, and for those of the Canal Bridges 55 feet Span - wood work of Earth Waggons for the Railway &c" &c" &c" -

35 - From the little success that attended Lieutenant Strachey's arrangement for contract - Bricks - and from the difficulty of obtaining fuel for Hindostanee kilns - it soon became apparent that we must depend for our chief supply of this material on our own kilns - burned with wood fuel - A small commencement of the arrangements for this purpose - was made in 1845 - after the close of the Sutledj campaign, but it was then too late in the season to obtain any satisfactory results - In the cold weather of 1845/47 - a number of new kilns were built both at Roorkee and Mutheura, and considerable quantities of

firewood were cut in the forests and carted to the works. During the early part of the season, many circumstances combined to render the results of these operations very unsatisfactory. Great pains had been taken to ascertain the method of burning Bricks with wood, as practised at Umballa and elsewhere - but our people did not at first get into the way of loading the kilns properly, and this combined with a long duration of unfavorable weather, and the green-ness of the firewood, rendered the operations of the cold weather months almost entirely unprofitable - At the commencement of the hot season, however, a change for the better became apparent: two new descriptions of kiln were tried with better success, and before the setting in of the rains, we had turned out about 38 Lakhs of serviceable Bricks from the English kilns. Early in October of the present season, the Brick making operations were resumed under the supervision of Mr. J. Finn, appointed Executive Officer for the preparation of Materials in the Northern Division. —

36. The experience gained in our former unsuccessful operations, and the Establishment and workpeople who had been employed in carrying them on, were made available to Mr. Finn together with a considerable stock of dry firewood, and these advantages combined with that of Mr. Finn's undistracted attention being

being given to this branch of the work, have evidently sold on the cost and quality of the Bricks. Their price, however, is still very high, being for these three months operations not less than 1000 Rupees per Lakh for Pukka Bricks 9½" thick and 250 Rupees for Kucha Bricks, and I fear that with the present descriptions of Kilns, no material reductions in this price can be looked for. Improvements, however, will doubtless suggest themselves, and a very promising experiment has lately been made with a new kind of kiln, such as is used in Scinde, by which it is hoped that a considerable saving both in fuel and labor may be effected. Hindoostani kilns are also being established in localities where the appropriate fuel is obtainable, within such distance from the Roorkee works as will admit of their being brought in at a reasonable cost. A few of these Hindoostani kilns are contracted for by parties on whom Mr. Finn thinks he may depend. the rest are being made by hired labor and under the supervision of Government Servants.

3/. The establishment of extensive Brick fields at Roorkee and Muheeun, has of course rendered necessary a great many subordinate arrangements, besides the construction of clamps & kilns. such as the formation of wells for supplying water, the construction of weighing machines &c. and the maintenance of a large Establishment of Bullocks and Carts with

sheds for their accommodation.-

38. Great efforts have been made (and with considerable success) to obtain Contract Carriage for Timber, firewood, bricks, Lime &c. but even were the extent of available hired Carriage greater than it is, it could not be so surely depended upon as to admit of our dispensing with our own Establishment of Bullocks. The supply of hired Carriage must at best be uncertain, and its failure at a critical period might be productive of infinite mischief to the works.-

39. In the 35th paragraph, I have adverted to the want of success attending our first attempts to burn bricks with wood fuel, but it may be proper to give some further details of these experimental operations of which the cost was considerable in itself- though small in comparison with the future expenditure- The first method tried at Roorkee was that employed with considerable success by Major Napier at Umballa- its failure with us, we now, by the light of experience, attribute to three causes. 1st. Using Dark wood, instead of Bukool or other hard wood- 2nd Using Koora instead of the light refuse of Chuppur Grass employed at Umballa to equalize the surface of the layers of wood- 3rd Ignorance of the proper management of the fire by means of the flues and the surface covering of ashes.- The second method attempted was that described in the 6th part (Vol: III) of Weales Quarterly papers on Civil Engineering- as that practised

in

in Holland - where wood fuel is often used - with us, however, it completely failed, the consumption of wood was greater than in the 1st. experiment and the result more unsatisfactory. The 3d. experiment was made with a "flame" kiln - such as is used in England with faggots, for which we substituted brushwood cut near the spot - a few good bricks were obtained by this method - but not in such proportion as to warrant a repetition of the experiment - The 4th method was recommended by a Native who chanced to be passing through Roorkee and offered to take service as a Brick-burner - His plans with a few exceptions, which did not appear to us very important, was the same as Major Napier's - but he understood the management of the fire, and the produce of his kilns was comparatively good. The 5th method was taught us by men whom we sent for from Benares - and which, I have since heard is described in the "Barrack Masters assistant" (of which there is no copy in the Canal Department) it is less certain than the 4th method, and more dependent on the quality of the wood - but the Bricks are less broken and of a better quality. A 6th method such as is practised in Scinde has lately been introduced with great promise of success - it is a flame kiln, but differs in some important respects from that just tried -

40. The Brick making operations of 1846/47

may be considered as experimental the expen-
-diture was £4,500 Rupees, the result 38 Lakhs
of Bricks or about Rupees 1435 per Lakh. -
During the present season, as far as it has
gone, the bricks have cost about 1000 Rupees
per Lakh, but may perhaps be eventually re-
-duced to an average of 800 Rupees per Lakh.
From this we may deduce that the cost
of our experience is about £4000 Rupees - or
3 per cent on the probable outlay on bricks.
Supposing that 1000 Lacks are required.

41. The Roorkee digging has undergone
annual repair, since my Connection with
the Ganges Canal, and is now in excellent
order. The upper slopes and Roadway drain
to the outside, and the Rain at Roorkee being
much less heavy than at Hurdwar - it has
not been necessary to provide masonry gutters
down the lower sloped as described in
paragraph 40. The slopes have been grassed.

42. From Hurdwar to the Mohunnoodpur
Falls - it has became necessary to modify the
Longitudinal Section first determined upon.
This necessity arose partly from an error
in the levels (to be adverted to again) and
partly because the excavation provided was
not sufficient to supply earth for the re-
-quisite Embankments - and still less so to
meet the requisitions of the Medical Committee.

In

In two places - Viz: between Adsfmuggur and Munglow - and between the latter place and Liberheri - there was not more than from 0 to 3½ feet of excavation which would have left the full water surface level of the Canal 6½ to 10 feet above the surrounding Country - The error above adverted to occured in a manner not easily accounted for - The levels of the Country along the proposed line had been repeatedly and most accurately taken, they had been connected with Major Cautley's Bench marks and the general agreement was highly satisfactory. The error in fact was not in taking the surface levels of the country, but in the calculation of the distance. The unexcavated space between the end of the Munglow and the beginning of the Muhoodpoor digging was miscalculated in excess by 5550 feet - and the fall or bottom slope assigned to that length was proportionately excessive. The canal bottom from the commencement of the Muhmoodpoor digging onwards was therefore 20½ Inches too low - It is obvious that such a mistake ought not to have occurred - but considering the scrupulous and laborious accuracy of Lieutenant Turnbull in taking the levels and laying down the directions of the straight and curved lines of the Canal - this one oversight may well be excused, nor as Director of the works, do I wish to evade my share of the blame, in failing to check the distances as well as the levels. —

43. The correction of the bottom level has been effected by giving a fall of 3 feet at the Asufmuggur Bridge and reducing that at Muhmoodpoor from 8 to 6·31. The results of this error have been in some respects convenient as we have combined with its correction, a desirable modification of the original Section, and have obtained Earth to complete the Embankments at a cost considerably below what must otherwise have been incurred. As a line of rails must have been laid down for that purpose.—

44. The following is the present state of the Earthwork in the Bungalow Division From the head of the Division to the commencement of the Lituriem Curve (1½ miles) the work is completed— from thence to Muhmoodpoor (4¼ miles) the Contractors are now employed— and the work is well advanced— From Muhmoodpoor to the Sand Hills near Doglutpoor (7 miles) the excavation is taken out to the full depth— The deep digging through the Sand Hills is not yet commenced the unexcavated space is about 1 mile— After which commences the Doglutpoor digging which is 3½ miles long and extends to the end of the Nugla Curve— up to which point it is complete and all in excellent repair.—

45. From the Nirganjni to the end of the Jowli Curve the Canal is lined out, the dagbels marked, and small brick pillars built at short intervals.—

46. I have merely further to remark with reference to the excavation of this Division - that the soil at the level of the Canal bottom from Mungloor to Mugla is very sandy and appears to me liable to future erosion by the strong current of the Canal - a process which must be met by permanent bars across the channel - The addition of masonry floors and curtain walls to the Bridges, would partially serve this purpose but if the disturbance shed be considerable, intermediate bars of Masonry, (in other works "pucca" sections of the canal) may be found requisite where the soil is bad.

47. The Military Board have supposed that the usefulness of the Ganges Canal, as an irrigating machine will be impaired by the adoption of the Medical Committee's recommendation - that the water should be kept within soil - Had it been intended to irrigate directly from the Canal itself. - the water must certainly have been kept generally above the surface level of the Country but such was not the case. Major Cautley always intended that the Water of the Ganges Canal should be distributed by means of Rajbuhas or main water courses, which would be of considerable length and having a less fall than that of the Country

would soon bring water up to the level of the cultivated land. With further reference to this arrangement the Canal will be taken along the highest ridge of the country. The adoption of the Committee's recommendations will not involve any material departure from Major Cautley's designs. A glance at his calculations for excavations, (pages 19 to 21 of the Estimates in the printed Report) will shew that the average estimated depth is in most cases sufficient to fulfil the prescribed conditions.

48. The Masonry works of the Munglour Division already completed, or nearly so, are the Munglour workshops, the 1st class chokies of Mukmoorpoor and Bairia, and the 2d class chokies of Munglour, Dimat, Goghulpoor, Nirgunjni, Bhopah and Jowli. The workshops are on a smaller scale than those of Roorkee, but will, I believe be found sufficient for the wants of the Division.

49. The 1st and 2d class chokies are built in accordance with the designs but with deeper foundations, with exception to the Mukmoorpoor Choki they are built on the embankments, as more convenient for the required purpose, though involving the necessity of carrying the foundations through the made soil to the natural surface of the ground. The walls of the 2d class chokies, are with the sanction of the Military Board, raised 3' higher than was at first proposed, to admit of the use of a punkha.

50. Of the Munglour and Goghulpoor Bridges

the

the foundations are complete - and of the former the Piers and Abutments are built to Spring of Arch. The original design for this part of the work has been considerably modified - I both in=stances the soil to the greatest depth to which I have examined it - Viz: 25 feet below the level of the level of the bottom of the canal - consists of sand, with a slight mixture of clay and having more or less solidity - I have therefore deemed it expedient to increase the depth of foundations from 10 feet to 12 and 15 feet according to soil, and to prevent the erosion of the Canal bottom, I have added front and rear Curtain walls and a ma=sonry floor - I have increased the surface Support=ing the structure, by adding a broad footing to all the foundations and I have reinforced the Abutments by the addition of strong counter=forts - As a set off to these additions the thick=ness of the Piers and of the Abutments between the Counterforts has been slightly reduced. -

51. - The excavation for founding several of the falls and Bridges of the Munglaur Division is in progress - In both cases the Channel at Site of the work requires modification - The width of the bridges between the Abutments is 179' - that of the Canal bottom being 140' it is arranged thus. -

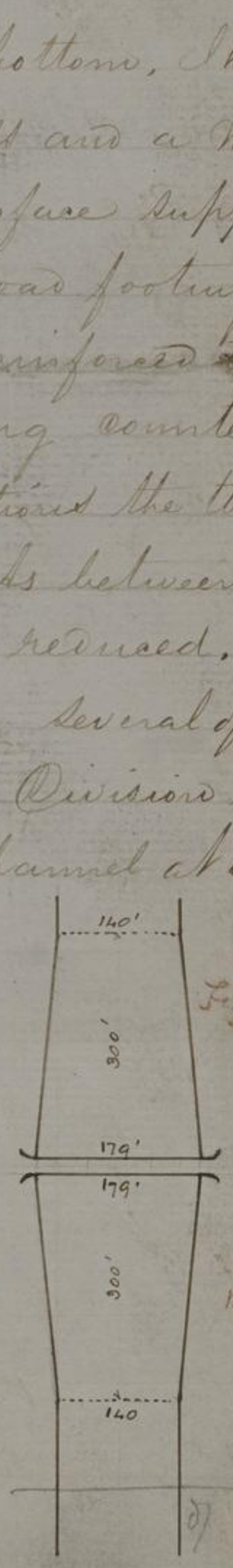


Fig. 10

B, 57.

The width of the falls between Abutments is 172½ feet - which alone bridge, is similarly accommodated

to the width of the Canal. Below the bridge I have deemed it better to adopt at once, the form of Channel (as per margin) which the action of the water would inevitably cut out for itself. I would further strongly recommend the addition of the Curved Revetments a a.

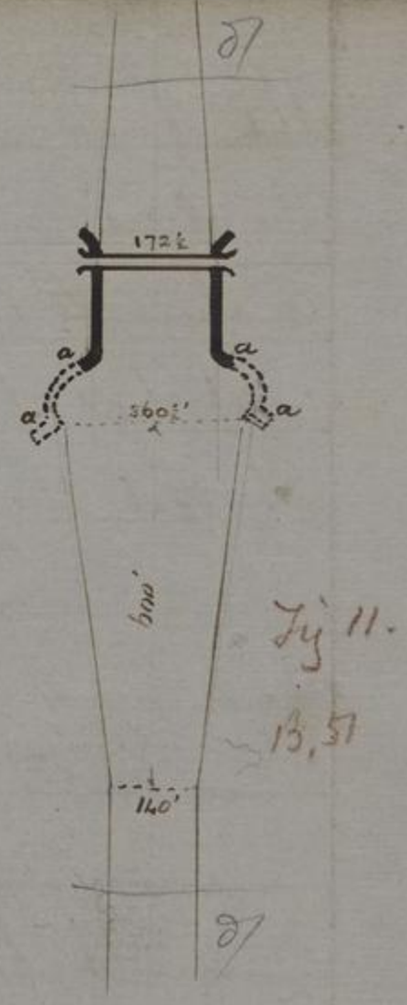


Fig 11.
13, 57

52. I may here remark that previous to the preparation of working plans for any bridge the Executive Officer examines the soil to a depth of 25 feet below the canal bottom, by means of 3 Vertical Shafts or Kucha Wells - and sends to the Director's Office, a report of the results - and Specimens of the soil taken at every 2½ feet. These Samples are kept in the Model Room, and a sheet of sections is also prepared, shewing the depth of foundation of each work and the nature and succession of strata at its site.

53. The greatest difficulty in this Division has been experienced in burning Bricks. The Kora required for fuel being highly prized by the Cultivators, and no Communications passable with by them. The requisite numbers for the several bridges have now, however, been nearly completed, and either wholly or in part carted to and stacked at the sites of the works. The larger numbers required for the Falls are not yet complete - nor at the present rate of progress, could they be got ready in many years. Arrangements will therefore be made to burn them with wood -

wherever

wherever that description of fuel is obtainable at a reasonable cost.

54. The Bricks as they are unloaded from the kilns are taken to the sites of the Works, and it is my wish that when sufficient for that purpose are collected, the foundations should be got in at once as the most convenient way of disposing of the Bricks and releasing the ground covered by the stacks.

55. In the 3rd or Bolmershurst Division under Mr. Wolk - in the 4th or Tuttlehgunk Division under Lieutenant Hodgson and the 6th or Caunpoor Division under Lieutenant C. W. Hutchinson, the preliminary examination of the country is in active progress, and printed instructions have been issued for the guidance of the Executive Engineers. No Executive officer has yet been appointed to the Etawa Division - but Mr. Dodsworth is engaged in taking a series of levels in that direction.

56. In conclusion it is but justice to the Executive officers and assistants on the Ganges Canal, and more especially to Lieutenants Thatcher, Turnbull and Cole, to state to the Military Board my high estimation of the zeal, ability and good feeling which has animated their exertions in forwarding this great work. The Executive Officers have had to struggle with many difficulties, the conquest of which, though it has smoothed the path of their successors, has doubtless enhanced the cost of their own work - and it is

important to bear this in mind, and to be cau-
tious in drawing unfavorable comparisons be-
tween the cost of the past and future work, and
in attributing to the superior care and manage-
ment of future Executives any improvement in
economy which may be chiefly due to the re-
sults of their predecessors labours. The force
requisite to maintain the regular and equable
motion of a vast machine, is no measure of
the force required to set it going. —

(Sd) W. E. Baker, Major
Director Ganges Canals.

APPENDIX

F

Appx - J

(1)

CALCULATIONS FOR DISCHARGE

The following points being conceded as axioms, the data for the discharge, and the capacity for the Canal channel have been framed upon them:-

1st That a discharge of 1 cubic foot per second constant, is equal to the irrigation of 350 beegahs of 55 yards square each.

2dly That from the results of the Delhi and Doab Canals 000 cubic feet per second constant, is a fair supply for irrigation for 100 miles in length of a Canal.

3dly That taking village estates with reference to their general character a proportion of surface equal to one-third of the whole, is a fair proportion requiring irrigation.

2. On each 100 miles in length therefore, the Canal would, on the 2d axiom, irrigate 280,000 beegahs or 273.4 square miles, and on the 3d axiom, this would be sufficient for an area of country equal to three times that amount, or to 820·2 square miles.

3. I assume therefore, that a strip of country on each side of the Canal from 4 to 5 miles, say 5 miles in width, would be irrigated. The beneficial effects of irrigation being open to distant lands, when those in the immediate neighbourhood of the Canal were not suited to irrigation.

4. Now the Ganges Canal on Project No. 1, is proposed to run in an uninterrupted and direct line from Hurdwar to Allahabad - the total distance being 453 miles, from this main line branches will be taken off towards Futtigurh, Tuppul in the Bolundshuhur District, Etawa and Cawnpoor.

5. The first part of the line, viz. that from Hurdwar to the village of Nusseerpoor, (27½ miles in length) may be considered as removed from the influence of irrigation, from its passing through Khadir land in the early part of its course, and deep digging immediately above Nusseerpoor; there remains therefore 425½ miles, requiring as above 3404 cubic feet of water for irrigation on the main line only.

6. The length of the branches are as follows:

Futtigurh, - - - - -	160 miles.
Bolundshuhur, - - -	70 do
Etawa - - - - -	172 do
Cawnpoor - - - -	43½ do

For the first five miles of these branches, the country may be considered under the influence of the main line, as far as irrigation is concerned. The total length of Canal therefore, including both the main line and the branches, for which irrigation must be provided, is as follows:-

Main Line, - - - - -	453	- 27½	=	425½ miles
Futtigurh Branch, -	160	- 5	=	155 do
Bolundshuhur Do,	70	- 5	=	65 do
Etawa - - - Do	172	- 5	=	167 do
Cawnpoor Do	43½	- 5	=	38½ do
Total number of Miles -				851

By referring to the sheet of sections of the main line, it will be observed that throughout the whole of the Futtipoor and Allahabad Districts, or on the last 100 miles approaching the terminus, the excavation of the Canal channel is so deep, that although Cuts may be taken off at right angles for the purposes of irrigating distant lands, the fields in the immediate vicinity of the Canal will, with difficulty, be supplied with water, and that only by machinery. I have therefore reduced the supply of water for virigation on this lower tract from 8 to 4.92 cubic feet per second for each mile - turning the difference to a more useful account in the Cawnpoor District.

7. The distribution of the whole body of the Canal supply therefore, which is calculated at 6750 cubic feet per second, and which is supposed by the Committee to reach the high land of the Doab at Rookhie, will be thus -

Main Line, ———	425½ miles	325½	at 8 cub. ft pr mile,	2604
		100	at 4.92 do do	492
			Total for Main Line, — —	3096
Futtigurh Branch,	155 miles —		at 8 cub. ft per mile,	1240
Bolundshuhur Do	65	do ———	do ———	520
Etawa ——— Do	167	do ———	do ———	1336
Cawnpoor — Do	38½	do ———	do ———	308
Reserved portion for navigation at Allahabad —				250
			Grand Total ———	6750

8. The detail of discharges at the heads of branches, with that for the computation of the capacity of the main channel, and transverse sectional area of excavation will be thus–

1st	Distance from the head at Hurdwar to the departure of the Futtigurh Branch, –	50 miles
2d.	Futtigurh Branches to Bolundshuhur Branches	60 do.
3d.	Bolundshuhur Branch to Etawa Do	70 do
4th	Etawa Branch to Cawnpoor Do	100 do
5th	Cawnpoor Branch to Terminus at Allahabad	173 do
	Total Length, –	453 miles

As noted in the 5th paragraph of this Appendix, 27½ miles must be deducted from the first item, leaving 22½ out of the 50 miles to be supplied with water for irrigation. From this results the following Table:

Expenditure on the Main Canal to below	Water demanded for Irrigation		Discharge below Branch on the Main Line
	Main Line	Branch	
Futtigurh Head	6750 – (180 + 1240)		= 5330
Bolundshuhur Do	5330 – (480 + 520)		= 4330
Etawa Do	4330 – (560 + 1336)		= 2434
Cawnpoor Do	2434 – (800 + 308)		= 1326
To Allahabad	1326 – (1076 + 0)		= 250

Leaving for the purposes of Navigation 250 cubic feet per second

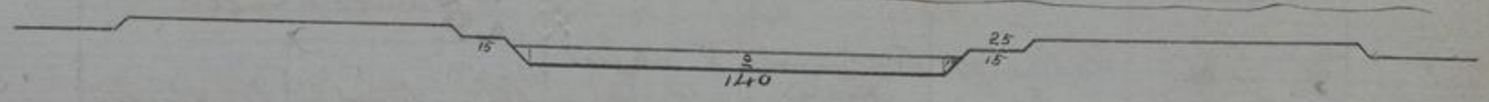
22 14 18

9 The dimensions of the main channel are represented in the following sections:–

B

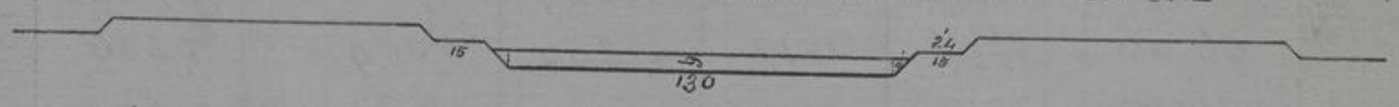
No 1

From the Head of the Main Canal to the Futtehgurh Branch head distance 50 mile



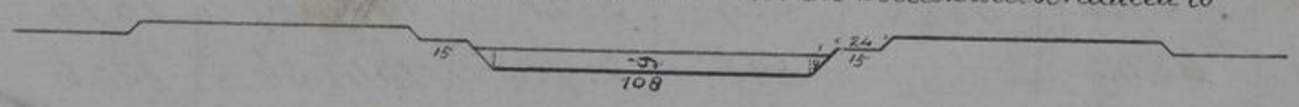
No 2

From the Futtigurh Branch Head the Section will be reduced to:=



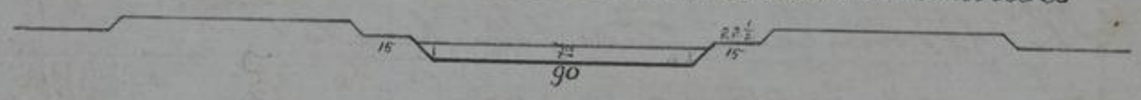
No 3

From the Bolundshuhur Branch Head the Section will be reduced to



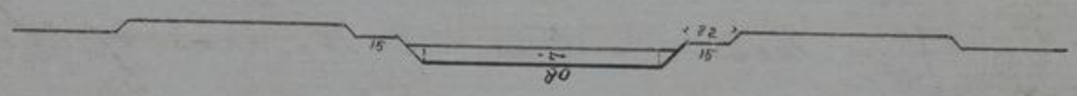
No 4

From the Etawah Branch Head the Section will be reduced to



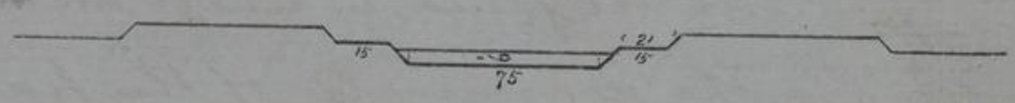
No 5

From the Commencement of the 250th Mile the Section will be reduced to



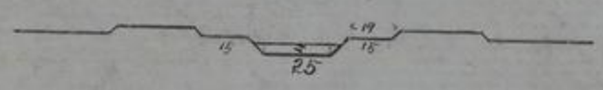
No 6.

From the Commencement of the 281st Mile or from the Cawnpoor Branch the Section will be reduced to



No 7

At the Terminus the Section will be reduced to



The capacities of these sections are as follows:- The values of R and $\frac{1}{b}$ being calculated on no fractional parts beyond .5 in the former, and in round numbers in hundreds in the latter:-

Section	Value of R	Value of $\frac{1}{b}$	Sectional area Square Feet	V in feet.	Discharge	
					Theoretical	Required
No. 1	106.96	$\frac{1}{3520}$	1500	4.469	6703.5	6750
2	96.56	$\frac{1}{3520}$	1251	4.244	5309	5330
3	94.68	$\frac{1}{3520}$	1053	4.203	4425.7	4330
4	78.91	$\frac{1}{4224}$	731.25	3.474	2540.36	2434
5	73.24	$\frac{1}{4546}$	609	3.21	1954.89	1874
6	63.43	$\frac{1}{5280}$	486	2.763	1341.36	1326
7	38.34	$\frac{1}{5200}$	116	2.109	244.644	250

54 6 6 7 7 9 7

The formula is thus, (Dubuat)

$$V = \frac{306.55\,(\sqrt{R} - 0.10325)}{\sqrt{b} - \text{Hyp. Log. } \sqrt{b} + 1.6} - 0.31\,(\sqrt{R} - 0.10325)$$

When V = mean Velocity per second

R = Mean Radius, i.e. the area of the section in square inches, divided by its wall, or that part of the Perimeter in contact with the fluid, in linear inches.

$\frac{1}{b}$ = The denominator of the fraction expressing the slope of the bed, or surface of the water, the Numerator being unity, so that a slope of one inch in one thousand is equal to $\frac{1}{1000} = \frac{1}{b}$ and $b = 1000$.

The ratio between the velocities at the surface, and those at the bottom, is exhibited in the following table, where $\underline{v}$ denotes the former and V the latter. The surface velocities have been

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deduced from Dubuat's formula: and the values of V and U of both Dubuat and Prony have been calculated.

Section	Values in feet of v	V		U		Slope of Canal bed per mile in Inches
		Dubuat	Prony.	Dubuat	Prony	
No. 1	5.13	4.46	4.15	3.79	3.18	18
2	4.88	4.24	3.95	3.60	3.02	18
3	4.83	4.2	3.91	3.57	2.99	18
4	4.04	3.47	3.27	2.90	2.50	15
5	3.77	3.21	3.05	2.65	2.33	14
6	3.27	2.76	2.64	2.25	2.02	12
7	2.55	2.1	2.06	1.65	1.58	12
	3.08	2.58	2.49	2.08	1.90	12
	3.20	2.69	2.59	2.18	1.98	12
	3.30	2.78	2.67	2.26	2.04	12

5/- 7

Dubuat

$v = (\sqrt{V} - .3 + .55)^2$

$V = (\sqrt{v} - .55)^2 + .3$

$U = 2V - v$

Prony

$v = \frac{V}{.81}$

$V = .81v$

$U = .62\ v$ { Preserving the rule quoted in the note *.

With regard to the effect that the maximum velocity at the bottom, agreeably to the above table, may have upon the soil at the bed of the Canal, I am only able to draw inferences from what has occurred on the Doab Canal, where the disarrangement of the bed, depending not only on excess of slope, but on the irregularity with which that slope existed, was great; the points in the bed which suffered severely were those where the declivity per mile varied from 4 to 4½ feet, or where, agreeably to the above formula, the velocity of

* Prony having given no formula for the value of U, it has been calculated on Dubuat's rule $V = \frac{v+U}{2}$.

the current at the bottom was equal to 4.1 and 6.6 feet per second of Dubuat, and 3.39 and 5.25 feet per second of Prony. From 2 to 4 feet declivity per mile the action on the bed varied agreeably to the nature of the soil over which the current passed, but this action was not dangerous, though it must have been greatly influenced by the constant change of situation in the deposits of silt which took place at this period. In remodelling the slopes a maximum declivity of 2 feet per mile was determined on, which with the supply that the canal might be expected to hold, would on the above formula give a velocity at the bottom equal to 3.5 or 3 feet per second. Up to the present period we have not had the means of testing the action on the remodelled slopes (from circumstances unconnected with these enquiries the proposed slope of 24 inches was reduced to 23 inches per mile;) with a mean radius of section greater than 40.7, this gives a velocity at the bottom equal to 2.7 and 2.3 feet per second, which might certainly be considerably exceeded, as far as I am able to judge from the stable state of the canal bed; the soil is good.

It will be observed that in the project for the Ganges Canal, the declivity of bed is less than that above alluded to, but the magnitude of the mean radius of the section gives a velocity to the current due to the greater slopes of the Doab Canal. I have no reason for anticipating any dangerous

effects from this velocity, but at the same time I would recommend, that the branches should not be commenced upon, until the main line is completed, and the action of the water necessary for that line, carefully observed: a decrease in depth of water to the 1st section equal to 3½ feet would reduce the current at the bottom of the Canal to 3.07 and 2.64 feet per second of Dubuat and Prony respectively, & would give a supply equal to 3494 cubic feet per second, which is somewhat more than is required for the purposes of both irrigation and navigation.

The following table is explanatory of the capabilities of the Solani Aqueduct, the depth of water being retained as in Section 1.

	area of Section in feet	R	$\frac{1}{b}$	Values in feet of					Discharge per second
				v	V		U		
					Dubuat	Prony	Dubuat	Prony	
Earthen Aqueduct Revets	1590	101.	$\frac{1}{3520}$	5.0	4.35	4.05	3.7	3.1	6916
Masonry Aqueduct	1700	97.1	$\frac{1}{3520}$	4.87	4.23	3.94	3.59	3.01	7191

11 4

Were each of the masonry channels reduced to a breadth of 82½ feet, the equilibrium between their total value and that of the Earthen Aqueduct, would be more perfectly established, but the stone piers which are fixed in the bed of the channels at both extremities, may probably have some effect in interfering with the current, an evil which will be qualified by this additional width.

The formula for afflux (or rise to the waters surface level on the superior side, arising from the construction of a bridge over the course of a river, which has been used, is this -

$$\left(\frac{V^2}{2G} + p\right) \times (K^2 - 1)$$

V = mean velocity of current before the erection of the Bridge.

K = ratio between sectional area of the river & the aggregate waterway of the Bridge.

p = difference of level on contracted or narrowed part of the river.

G = the acquired velocity at the end of one second by a ponderous body falling freely, this is always an uncertain part of these equations, the reasons for which are explained by Dubuat; it has been used throughout my calculations. as 330.

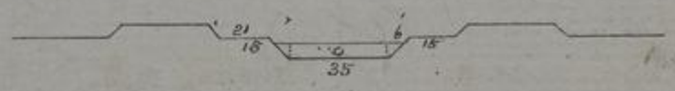
10. The berms of the Canal, or the space between the interior slopes of the embankment and the channel are proposed to be raised 12 inches above the high water mark, and the top of the embankments are not to be less than 3 feet above the same level. The Terreplein or top of banks to be not less than 20 feet wide, excepting on the last 100 miles of the Canal where this minimum width may be reduced to 16 feet, where earth is in excess the extra soil will be used in extending the width to the rear; where there is a deficiency, the earth required for the completion of the banks to their full height and width, will be obtained by digging superficial trenches, not deeper than 12 inches, either within or without the Canal boundary; if without, the sides ought to be sloped off, so as to admit of a plough passing over them. The limits to the

Canal ground ought to be marked off by a ditch 3 feet wide and as much deep.

Cawnpoor Branch

11. Forty-three and a half miles long with a slope of 12 inches per mile – the supply for this branch is 308 feet per second. The masonry head at Rousa, from which it receives its supply, consists of two openings of 20 feet each. The capacity of channel at the point of departure is

Fig 9:



1 in 3,55.

Section	Value of R	Value of $\frac{1}{v}$	Sectional area Square Feet	V in feet	Discharge	
					Theoretical	Required
At the point of departure	56.81	$\frac{1}{5280}$	246	2.584	635.66	308.
	4	4	6	4	6	5

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These dimensions decrease to a width of 21 feet until the branch terminates at the escape into the Pandoo at Gouri. The capacity of this channel is sufficient for twice the quantity that the supply for irrigation demands, to admit of surplus water being thrown down it.

Ground occupied by the Canal.

12. It is proposed that Plantations of Forest Trees should be established on each side of the Canal – the berms, slopes and embankments being kept entirely free from either trees or vegetation. Where, however, the Terreplein or top of bank exceeds the proposed width of 20 feet, it will be desirable to keep a space not exceeding 30 feet in width clear for the purposes of a road way.

It will be evident on a reference to the table of excavation that beyond that required merely for the formation of embankments, much superfluous earth will remain, this would be spread out up to the boundary ditch. On the early portion of the Canal the excavation is so extensive, that the whole of the land within the boundaries will be raised to the height of the Terreplein; with the exception, however, of the berm, slopes, and the roadways, the whole will be planted: the superficial area of land which the Canal will occupy on No. 1 Project, may be estimated as follows:-

Main Line.

		Length Feet		Breadth Feet		Area	Total Acres
On Section No.	1	264000	×	600	=	158400000	
	2	316800	×	400	=	126720000	
	3	369600	×	300	=	110880000	
	4	369600	×	250	=	92400000	
	5	158400	×	200	=	31680000	
	6	913440	×	150	=	137016000	
					Total - - -	657,096,000	
Then $\frac{657096000}{43560}$							15084.84
Cawnpoor Branch		229680	×	150	=	34452000 =	790.90
Futtigurh Do		844800	×	200	=	168960000 =	3878.78
Bolundshuhur Do		369600	×	150	=	55440000 =	1272.27
Etawa Do		908160	×	200	=	181632000 =	4169.69
Total amount of Land required for the Main Canal and its Branches on Project No. 1.							25196.48

13. In addition to the above, it is proposed to establish Orchards of grafted Mango trees at every 1st Class Chokie, or at every 15 miles or thereabouts - each orchard to consist of 5 acres - these may hereafter be extended throughout the branch lines, but the main line only is now

taken into consideration - it will also be necessary to take in a portion of ground at Roorkhie for the Work Shops, Timber Yard, Brick Ground and for general purposes - the additional space required under these heads may be estimated at 250 acres, viz.

34 Orchards × 5 = 170
Roorkhie Ground 80
Total 250 acres.

The object in combining with the plan for Plantations of Forest Trees, one for the grafted mango, is to take advantage of the means of protection and care offered by the Canal Establishment in introducing generally on the whole line of the Doab a fruit which in its natural state is highly prized by the native community, and which when cultivated will be still more acceptable. The Orchards will be annually farmed out, and the proceeds set off against the expenses of original outlay and maintenance: each Orchard will be the nucleus of distribution for grafts when the parent trees have arrived at maturity, and it may be inferred that by the means proposed, a very superior fruit will be generally disseminated.

14. In the above calculations the total area of land required for the purposes of the Ganges Canal and its branches, will be equal to 25196.48 acres, say 25200 acres, which, at an average of 2 Rs. 8 annas per acre, leads to an annual remission of Rs. 63,000. It may appear at first sight that this sum, which is annually

disbursed from the treasury as long as the present assessments last, and the equivalent of which in the land itself is struck out of the Jumma when the next settlements take place, is not only an annual and permanent loss to the Government but a dead weight upon the Canal Returns: it must be recollected however, that the consequence of introducing facilities for irrigation, are increased value of property, and a security to the realization of the Government revenue: I merely advert to the direct benefits to the State as exhibited in the Treasury Receipts, and that these benefits will far counterbalance the remission for land taken up originally for the Canal purposes, appears to me to be evident.

15. Independently however of remission for land occupied by the Canal, the items of remuneration for standing crops, trees, buildings, wells, &c present themselves, it is hardly possible to determine the exact amount which may be carried to this account. It would be a necessary part of the Superintendents duty however to make such arrangements as might prevent, as much as possible, the removal of standing corn, sugar-cane, cotton, &c by postponing the excavation of the Canal at points where they existed, and giving warning to the cultivators not to sow within the limits of the Canal boundaries, when such boundaries had been distinctly laid down, I am not therefore disposed to estimate the

remuneration on this item at a high amount Trees and masonry wells would have to be paid for when actually removed, but I would restrict this removal to that portion of the Canal limits occupied by the banks, berms and channel. On that portion within the boundary devoted to plantations, the trees standing might be allowed to remain, as the property of the owner, until he wished to remove them, and the wells might continue in use for irrigation, without in any way interfering with the interests of the Canal: this might be laid down as a general rule, the exception being where removal was necessary, in which case remuneration would be given.

16. The remark however appended to Para. 14 is equally applicable here, the original outlay on remission and remuneration, whether for land, crops, trees or buildings, would meet with an ample return in the increased value of estates and property.

Ganges Canal Project No. 2.

17. Up to the 280th mile, or to the departure of the Cawnpoor Branch: there is no difference between this and the first Project, and Nos. 1 to 5 of the sections, with their calculated capacity for discharge, remain as before. In this Project however, the increased length of the Cawnpoor Branch, leads to a further removal of water from the main channel of 172 cubic feet per second, which (although for reasons before explained, no additional waterway is required at the head

of the Branch) renders a reduction to the section of the main line after the departure of that Branch convenient.

18. In continuation therefore from No. 5, section of Project No. 1, we have –

No. 6.

From the Commencement of the 281st mile or below the departure of the Cawnpoor Branch the section will be reduced to –

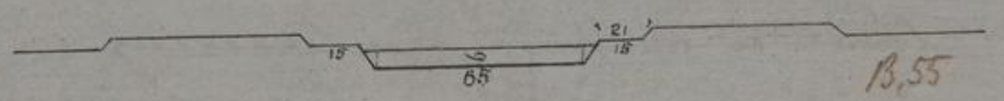

Fig. 20

No. 7.

From the commencement of the 361st mile the section will be reduced to – and continue to the Terminus

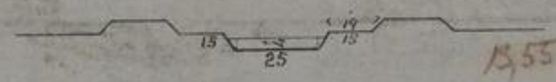

Fig 21

Section	Value of R	Value of $\frac{1}{n}$	Sectional Area Square Feet	V in feet	Discharge	
					Theoretical	Required
No. 6	62.37	$\frac{1}{5280}$	426	2.696	1148.49	1194
7	38.34	$\frac{1}{5280}$	116	2.109	244.64	250

	Water demanded for Irrigation		Discharge below Branch on the Main Canal
	Main Line	Branch	
The expenditure on the main line to immediately south of the Cawnpoor headby	2434 – 800 + 440 =		1194
To Allahabad	1194 – 944 + 0 =		250

1194 cubic feet per second passes the 280th mile for the purposes of irrigation and navigation – the length of Canal being 173 miles – for the first

80, of which an allowance is made for irrigation, agreeably to the 2d axiom of 8 cubic feet per mile, & to the latter from the reservoirs for lockage 3.26 cubic feet per mile - the disposal of the whole body being thus:-

For irrigation from the 280th to 360th mile, ... 640 C.F.
360th to 453d do. .... 304 "
For navigation, ... 250 "
Total Cubic Feet 1194

Stop Bridges will be placed on the Canal, south of the Cawnpoor Head and south of the Deosur Escape, to regulate this supply - and protect the Canal on its reduced section (commencing at the 360th mile) from being overloaded.

19. It will be observed that, on the above calculation, the quantity of water in the Canal, on its reaching the diminished section Figure No. 7, is equal to 614 cubic feet, whereas the capacity of channel upon which the above section has been framed is only equal to carry 244.64 cubic feet per second - by referring however to the depths of excavation from the 360th mile downwards, vide Estimate, it will be seen that they far exceed 4 feet, which as the minimum depth was that to be admitted into the calculations - the capacity of this channel therefore is fully equal to the quantity of water it will receive. I have been more willing to give an excess of water on this line, from the circumstance of the immediate neighbourhood of the Ghatumpoor Pergunna, in the Cawnpoor District, a tract of land lying to the south west of the

Town of Sark and the Fort of Kleosur, and greatly in want of irrigation. The Perguna in question, lies on the right or opposite bank of the Rinde River, but a Cut taken from the Canal at some point between Suchindee and Etarra, vide Sheet of Protracted Levels No. 9, would by the interposition of an Aqueduct built over the Rinde, provide this tract of land with ample means for irrigation.

20. This project will add in a small degree to the amount required for remuneration on land, viz. that for an additional length of 16½ miles to the Cawnpoor Branch, thus-

$$\underset{16\frac{1}{2}}{\text{Miles}} \text{ or } \underset{87120}{\text{Feet}} \times \underset{150}{\text{Feet}} = \frac{\underset{13068000}{\text{Sq. Feet}}}{43560} = 300 \text{ acres}$$

Brought forward, ... 25196.48

Total Land required for No. 2 Project 25496.48

No. 3 Project.

21. Up to the departure of the Cawnpoor Branch, at the 280th mile, the calculations remain the same as in the former Projects; from the point of separation each Branch, viz. that one towards Allahabad, and that to Cawnpoor, are projected as lines of navigation, the former being locked into the Jumna, south of the Rinde River, and the latter into the Ganges at Cawnpoor. The sections are as follows:-

No. 6

Allahabad Branch below Regulator at the point of Separation.

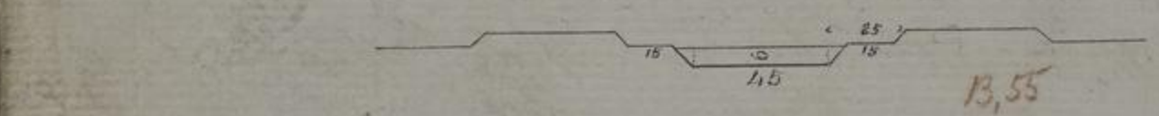

Fig 22

13,55

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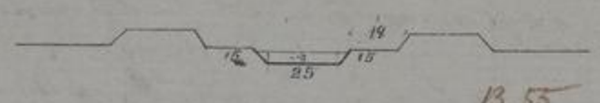
No. 7.

Allahabad Branch Terminus.



13,55

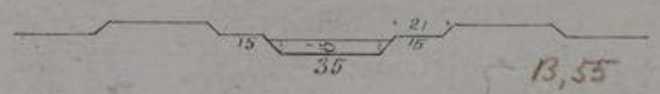
Fig. 23

Section	Value of R	Value of $\frac{1}{n}$	Sectional area Square Feet	V in Feet.	Discharge	
					Theoretical	Required
No. 6	64.46	$\frac{1}{5280}$	306	2.785	852.21	967.72
7	38.34	$\frac{1}{5280}$	116	2.109	244.64	250.

	Water demanded for Irrigation		Discharge below Branch on the Main Line
	Main Line	Branch	
Expenditure on the Main Line immediately South of the Cawnpoor Head being - - - - - - - - - -	2434 – 800 + 425.25 + 250		= 967.72
To Allahabad - - - - - -	967.72 – 717.72 + 0		= 250

No 6.

Cawnpoor Branch below Regulator at the point of Separation.

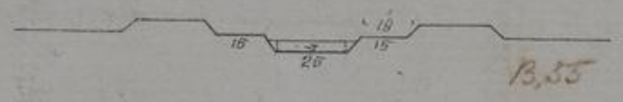


13,55

Fig 24

No. 7.

Cawnpoor Branch at Terminus.



13,55

Fig 25

Section	Value of R.	Value of $\frac{1}{n}$	Sectional area Sq. Feet	V in Feet.	Discharge	
					Theoretical	Required
No. 6	56.81	$\frac{1}{5280}$	246	2.584	635.66	666.28
7	36.34	$\frac{1}{5280}$	116	2.109	244.64	250.

On the Allahabad Branch a reduction in width of one foot takes place on each 5 miles. On the Cawnpoor one a similar reduction is made on every 6.

22. In this Project 1634 cubic feet per second reaches the point where the Allahabad and Cawnpoor Branches separate – out of which is reserved for the purposes of navigation 500 cubic feet per second, that is, 250 for the terminus of each. The remainder, which is applicable to irrigation, is divided off as follows:-

	Cub. ft pr. Sec^d.	Per mile
Allahabad Branch 100 miles has – – – – – –	717.72	or 7.0871
Cawnpoor Do 63 – 5 = 58 – – – – – – – –	416.28	or 7.875

This proportion of water per second for the supply of each running mile is somewhat less than laid down in the 2^d axiom of this Appendix.

23. The quantity of land occupied on this project will be as before, deducting 93 – 20 miles, or the difference between the length of Canal from the 360th mile to Allahabad, and that from the 360th mile to the Jumna near the mouth of the Rinde River.

Therefore as before, – – – – – – – – – – – – 25496.48 acres

Deduct.

$$385440 \times 150 = \frac{57816000}{43560} = \text{– – –} \quad 1327.27$$

Total Quantity of Land required for No. 3 Project 24169.21 acres

(Sd) P. T. Cautley, Capt.
Director Ganges C. Works.

APPENDIX

G

Report on the Water in the Hindun R... from the Point where the Bridge is building at Ghaziooddeen nugger, to its junction with the Jumna, near the Village of Mozabad, as... on the 4th, 5th, 6th, and 7th of April 1840.

Number of Station	Distance Feet	Width Feet	Width Ins.	Central Depth Feet	Central Depth Ins.	Remarks
1	1000	106	6	3	2	From No 1 to 36 taken on the 4th April 1840
2	1000	180	"	3	10	
3	1000	145	"	2	4	
4	1000	112	"	2	2	
5	1000	65	"	4	3	
6	1000	148	"	2	4	
7	1000	86	"	5	6	
8	1000	123	"	3	"	
9	1000	132	"	3	3	
10	1000	140	"	2	4	
11	1000	174	"	4	"	
12	1000	76	"	4	4	
13	1000	113	"	2	1	
14	1000	111	"	2	11	
15	1000	61	"	7	2	
16	1000	100	"	3	5	
17	1000	106	"	10	2	
18	1000	97	"	3	3	
19	1000	105	"	9	2	
20	1000	92	"	4	2	
21	1000	98	"	6	1	
22	1000	110	"	3	9	
23	1000	122	"	2	4	
24	1000	110	"	2	1	
25	1000	87	"	3	11	
26	1000	102	"	2	10	
27	1000	150	"	2	"	
28	1000	84	"	3	4	
29	1000	101	"	5	4	
30	1000	86	"	6	2	
31	1000	110	"	3	"	
32	1000	88	"	3	1	
33	1000	180	"	2	1	
34	1000	110	"	2	9	
35	1000	71	"	2	10	
36	1000	62	"	4	6	
37	1000	59	"	2	9	From No 37 to 79 taken on the 5th April
38	1000	65	"	2	2	
39	1000	92	"	2	4	
40	1000	89	"	3	2	
41	1000	83	"	3	"	
42	1000	93	"	3	10	
43	1000	131	"	2	2	
44	1000	111	"	3	4	
45	1000	108	"	3	6	
46	1000	75	"	8	2	
47	1000	137	"	2	3	
48	1000	101	"	2	4	
49	1000	63	"	3	7	
50	1000	55	"	5	2	
51	1000	98	"	4	1	
52	1000	99	"	3	2	
53	1000	113	"	3	"	
54	1000	94	"	5	6	
55	1000	105	"	2	4	
56	1000	63	"	3	5	
57	1000	76	"	4	2	
58	1000	71	"	4	1	
59	1000	61	"	5	1	
60	1000	89	"	2	6	
61	1000	132	"	2	1	
62	1000	75	"	3	1	
63	1000	85	"	2	"	
64	1000	78	"	2	8	
65	1000	50	"	11	4	

Distance	Width		Central Depth		Remarks.
Feet	Feet	Ins	Feet	Ins:	
1000	191	"	3	8	
1000	57	"	3	4	
1000	60	"	4	10	
1000	66	"	6	2	
1000	79	"	2	11	
1000	117	"	1	11	
1000	57	"	5	8	
1000	60	"	6	"	
1000	71	"	6	9	
1000	73	"	4	9	
1000	62	"	4	2	
1000	34	"	3	8	
1000	65	"	9	1	
1000	85	"	2	10	
1000	113	"	2	8	From Nos 80 to 124 taken on 6th April
1000	78	"	3	1	
1000	87	"	3	4	
1000	69	"	2	11	
1000	78	"	2	8	
1000	107	"	2	"	
1000	80	"	4	2	
1000	62	"	4	1	
1000	100	"	2	1	
1000	67	"	3	2	
1000	106	"	2	2	
1000	102	"	4	6	
1000	79	"	4	10	
1000	120	"	1	10	
1000	80	"	4	1	
1000	81	"	3	1	
1000	89	"	2	8	
1000	84	"	2	10	
1000	86	"	4	8	
1000	106	"	2	2	
1000	85	"	3	1	
1000	97	"	3	4	
1000	96	"	2	3	
1000	90	"	2	1	
1000	74	"	6	9	
1000	109	"	5	1	
1000	76	"	4	1	
1000	168	"	1	5	At Points Nos 107 and 108, where there is least water, is close to the Village of Pojus.
1000	151	"	1	4	
1000	89	"	2	2	
1000	68	"	2	8	
1000	114	"	2	11	
1000	92	"	2	3	
1000	95	"	2	1	
1000	105	"	2	5	
1000	82	"	10	7	
1000	111	"	2	11	
1000	83	"	2	4	
1000	130	"	2	"	
1000	108	"	2	2	
1000	68	"	2	8	
1000	138	"	2	6	
1000	106	"	2	11	
1000	58	"	5	11	
1000	74	"	4	2	From Nos 124 to 159 taken 7th April, 1820
1000	130	"	1	10	
1000	103	"	2	10	
1000	95	"	4	10	
1000	128	"	4	11	
1000	112	"	1	6	
1000	69	"	1	6	2
1000	74	"	6	1	
1000	112	"	3	2	
1000	127	"	3	2	11
1000	91	"	3	2	1
1000	120	"	3	2	1
1000	96	"	2	1	8
1000	89	"	2	1	11
1000	52	"	2	1	1
1000	101	"	2	2	10
1000	120	"	2	2	"
1000	139	"	2	2	"
1000	97	"	2	2	1
1000	141	"	1	3	11
1000	67	"	2	2	6
1000	80	"	2	2	6
1000	80	"	2	1	7
1000	100	"	2	1	10
1000	64	"	2	3	4
1000	82	"	2	3	"
1000	104	"	2	2	1
1000	137	"	2	1	1
1000	90	"	2	1	10
1000	68	"	2	1	10
1000	85	"	2	1	10
1000	89	"	2	1	11
1000	77	"	2	3	1
1000	73	"	2	1	9
1000	83	"	2	1	8
1000	94	"	2	1	2

(Signed) W. B. Brew
9th April 1820.—

APPENDIX

H

Circular Memorandum to all Executives on the Ganges Canal.

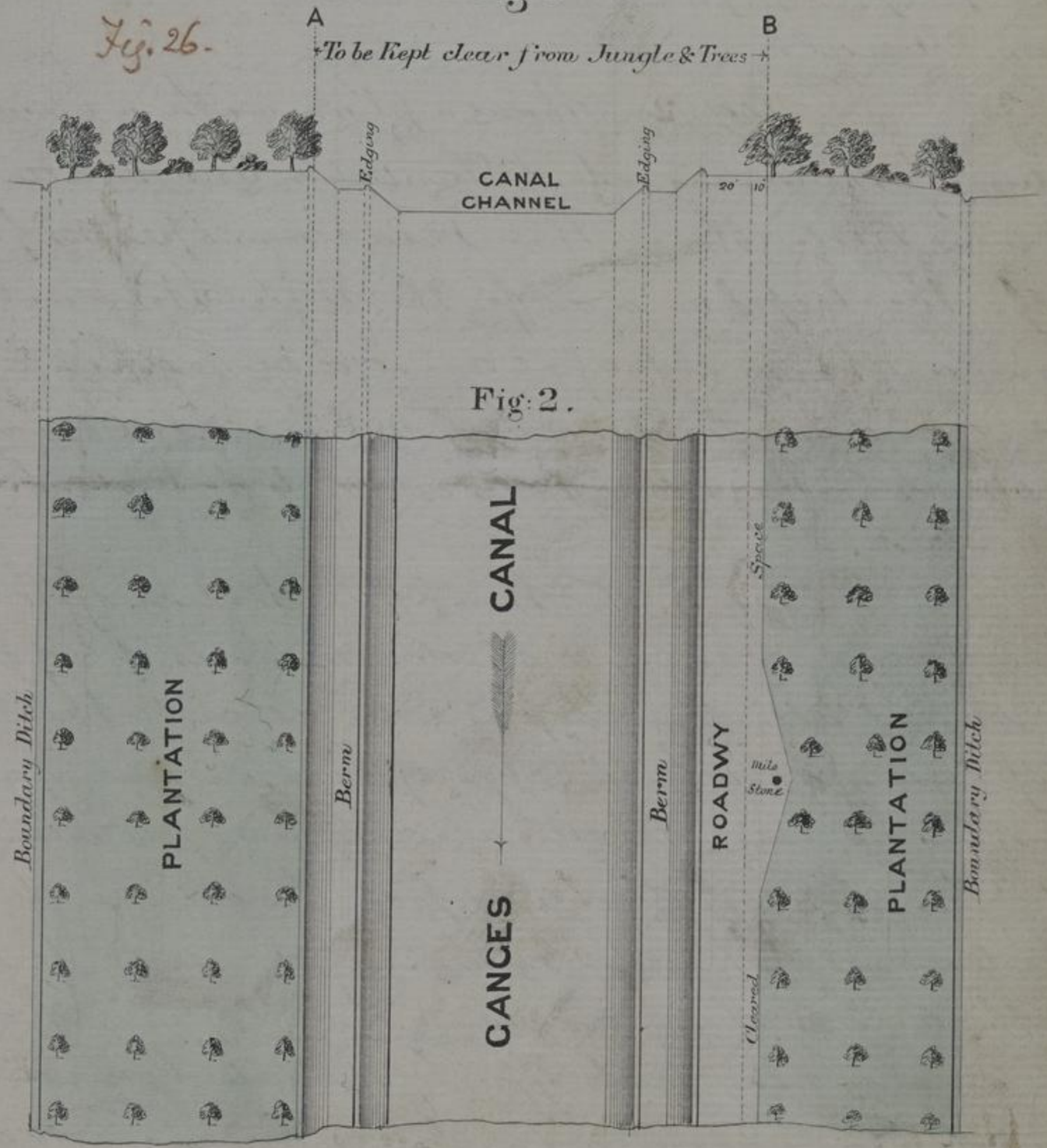
No. 82.

Dated 1st. January. 1852.

Plan and Section of Canal, with reference to Roadway, Plantations and ultimate annual clearance.

Fig: 1.

Fig. 26.



B, 57.

Fig: 2.

Fig: 3.

Fig 27.

B, 55.

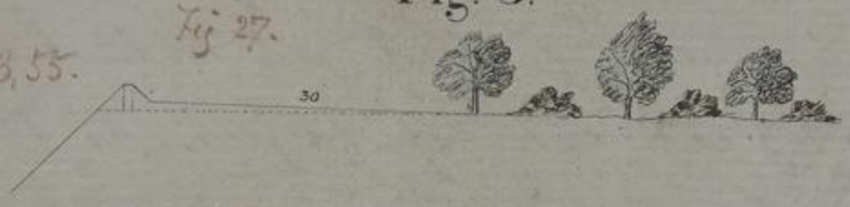


Fig: 1. Shows a Section of the Canal, as it is supposed to be, when the Plantations are

are established. These Plantations will, on the Right Bank of the Canal, be established from the boundary ditch to A, or to the crest of the interior Slope of the Embankment. On the Left Bank of the Canal the Plantations will be confined to the ground situated between the letter B and the canal boundary on that side.

The intermediate Space between A and B, including the interior Slopes, berms, Roadway &c and canal Channel, will be kept perfectly free from Plantation, as well as from Jungle.

Fig: 2. Shows a plan with a representation of the lining out of Plantation and Roadway at every Mile Stone; the Diagram speaks for itself; the Esplanade for the Mile Stone will have a chord of 150 feet and a versed sine depending on the width of artificial Esplanade existing. The mile Stones ought to be Centrically situated.

Fig. 3. Shows the Section of the Road on a larger scale, with dimensions of Edging- it shows also the Slope to be given to the 30 feet Esplanade which I propose to leave for the Roadway, and the Cleared Space parallel to it; this Slope is directed upon the outside, so that the canal Channel may not be interfered with. (my only object in giving the Slope is that the drainage may pass off to the outer boundary; any slopes, sufficient for this purpose, will answer, whether it is 3" or ½ an Inch.) The Roadway itself will be maintained clear from Jungle or impediment of any sort, it will be kept well rolled on a breadth of 20 feet, as shewn in the Diagram; the 10 feet in the rear which is intended to receive the dropping from the Trees and will relieve the Roadway from the

Projecting

projecting Branches, will be kept clear from Jungle, and it will act, in case of necessity, for Carts and Hackeries.

It is an object to keep the 20 feet Road free from Kunkur Metalling; but in very Sandy tracts, like those in the upper parts of the 1st and 2nd Divisions, either Kunkur or clay must be laid down; I prefer the latter as more suitable for Horses feet and more agreeable for walking on. When Doob Grass is fairly established, the Earthen Road becomes very firm and good, as is shewn in the Road Banks of the Alumna Canals. a stratum of ½ or 2 feet of good clay would answer every purpose I imagine.

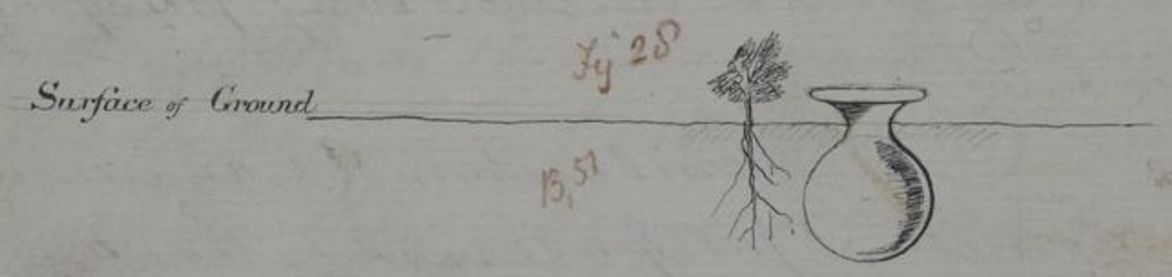
The Embankment roadways are for domestic purposes only, they are not intended for traffic or for general public use. Strings of Carts or cattle, of any description, are prohibited from coming upon the roadway, excepting in the train of a member of the canal Establishment; the Establishment are specially called upon to use this line for Patrol and Inspection purposes.

The latter end of March and beginning of April is a favorable Period for Tree planting, I take the opportunity therefore of pointing out, that I am very desirous of establishing lines of Mangoe Trees / not Grafts / along the canal Banks. Trees of this sort require great care and more looking after than others, and I wish to confine the Mangoe Tree-planting to two lines, one on the right the other on the left Bank. The position of the line on the left Bank is to be 10 feet in the rear

of

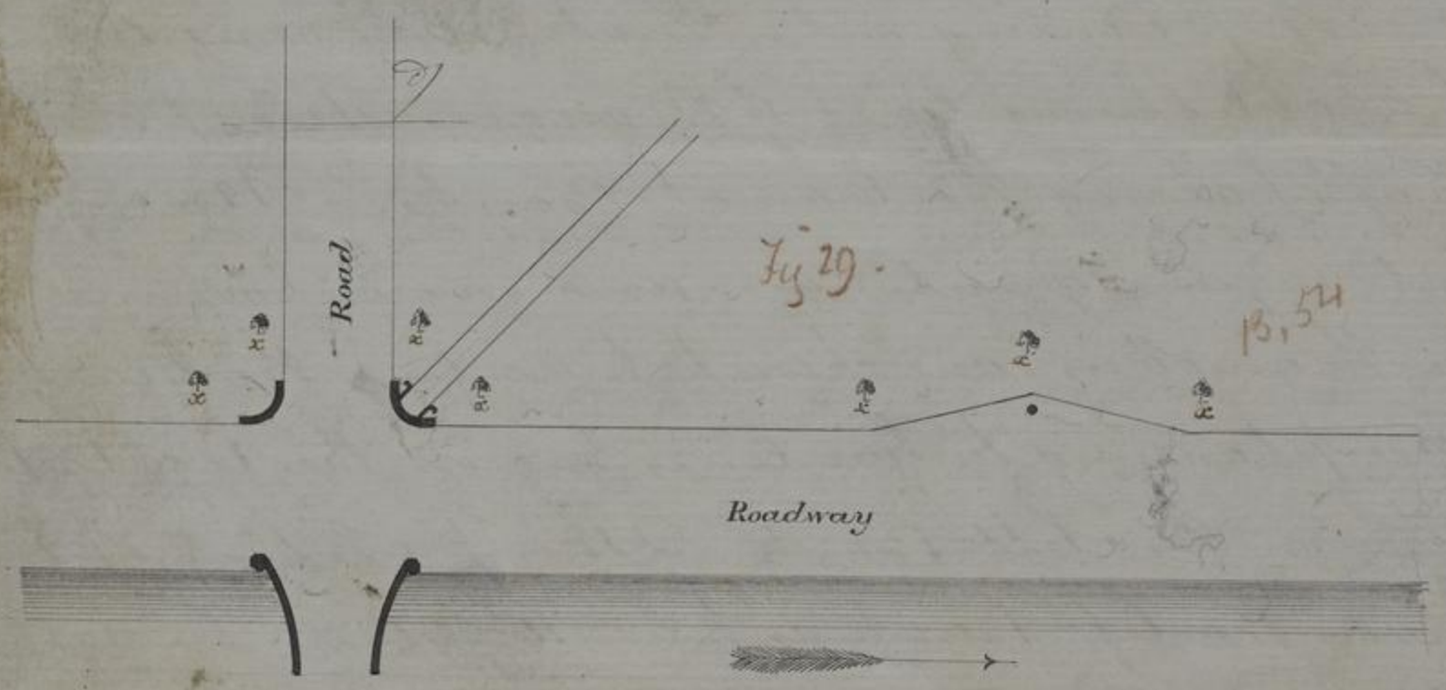
or on the left of the 30 feet passage for Roadway; that is to say, at a distance of 40 feet from the crest of the interior Slope of the Embankment. The position on the right Bank is to be exactly similar. viz. 40 feet to the right of the interior slope of the Embankment.

The Trees are to be planted at a distance of 100 feet from each other, so that about 53 plants will be required per mile. At the foot of each plant a Ghurra, or Kedgeree pot, in the bottom of which a very small hole is perforated, will be buried thus:



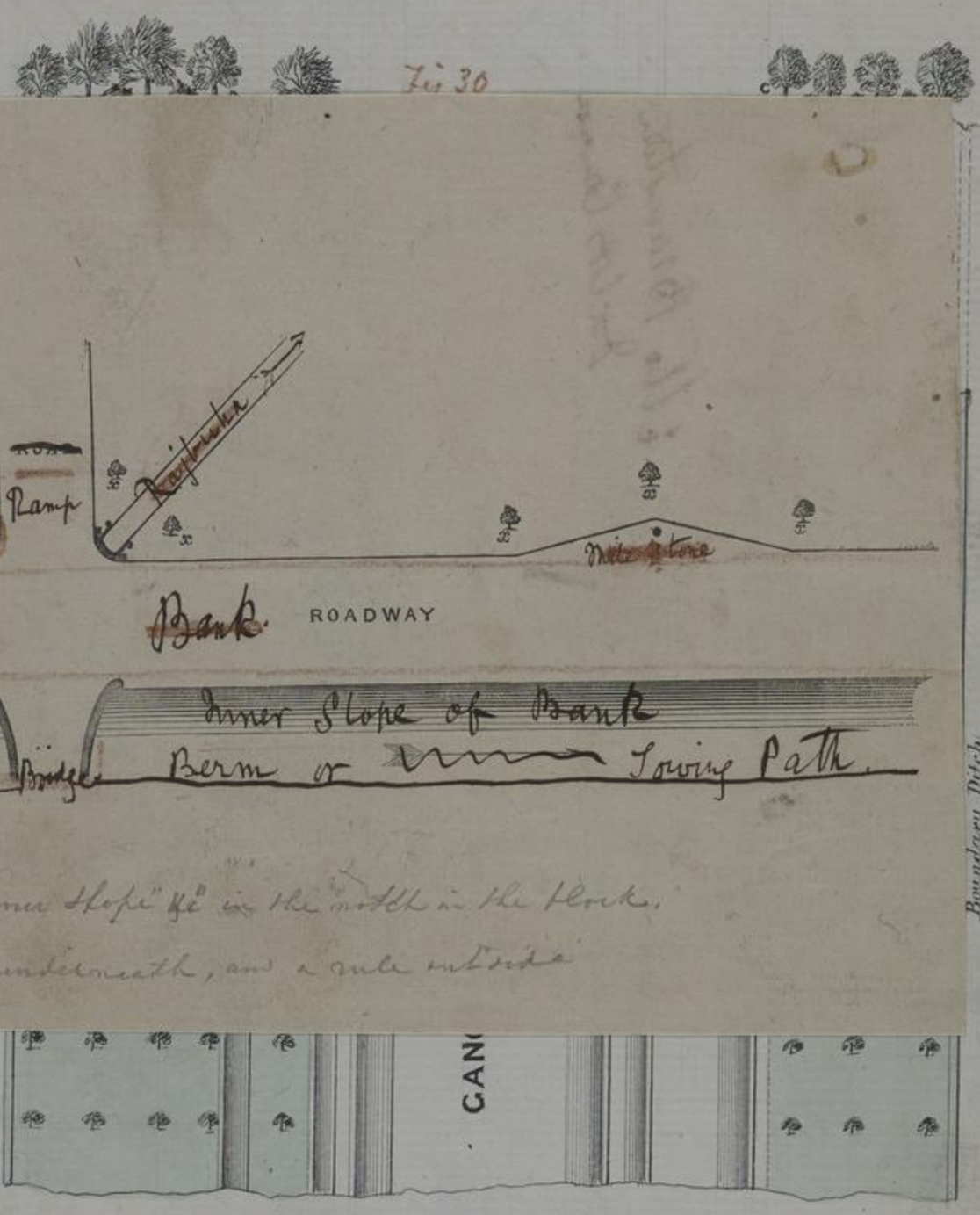
These Ghurras will be filled with water periodically and as frequently as may be considered necessary with reference to the moisture required.

I have stated that the Mangoe trees should be planted at distances of 100 feet; I would not diminish this distance, but I would so arrange that at Bridges and at Mile Stone posts, Trees might be thus situated - as at x. x. x. x.



I shall be glad to hear of the arrange=
ments above described being entered on in
the ensuing season.

The following Diagrams will
show the lining out which I propose
for the Roadways and Plantations in those
places where the Section of the Canal
is thus:



Set up "Inner Slope" 4ft in the notch in the block.
"Berm" 6ft underneath, and a rule outside

The Roadway, which is to be 20
feet wide, is to have a slight slope exter=
nally from A to B so that the drainage may
be carried off at the foot of the slope BC to
drains, as shown at x, which, being situated
at about 1,000 feet apart, will deliver the
water into the boundary ditches. I see

no

or on the left of the 30 feet passage for Roadway; that is to say, at a distance of 40 feet from the crest of the interior Slope of the Embankment. The position on the right Bank is to be exactly similar - viz 40 feet to the right of the interior slope of the Embankment.

The Trees are to be planted at a distance of 100 feet from each other, so that about 53 plants will be required per mile. At the foot of each plant a Ghurra, or Kedg

[illegible]

No Bluestone
Locks Canal

These

as freq

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minish this distance, but I would so arrange that at Bridges and at Mile Stone Posts, Trees might be thus situated - as at x. x. x. x.

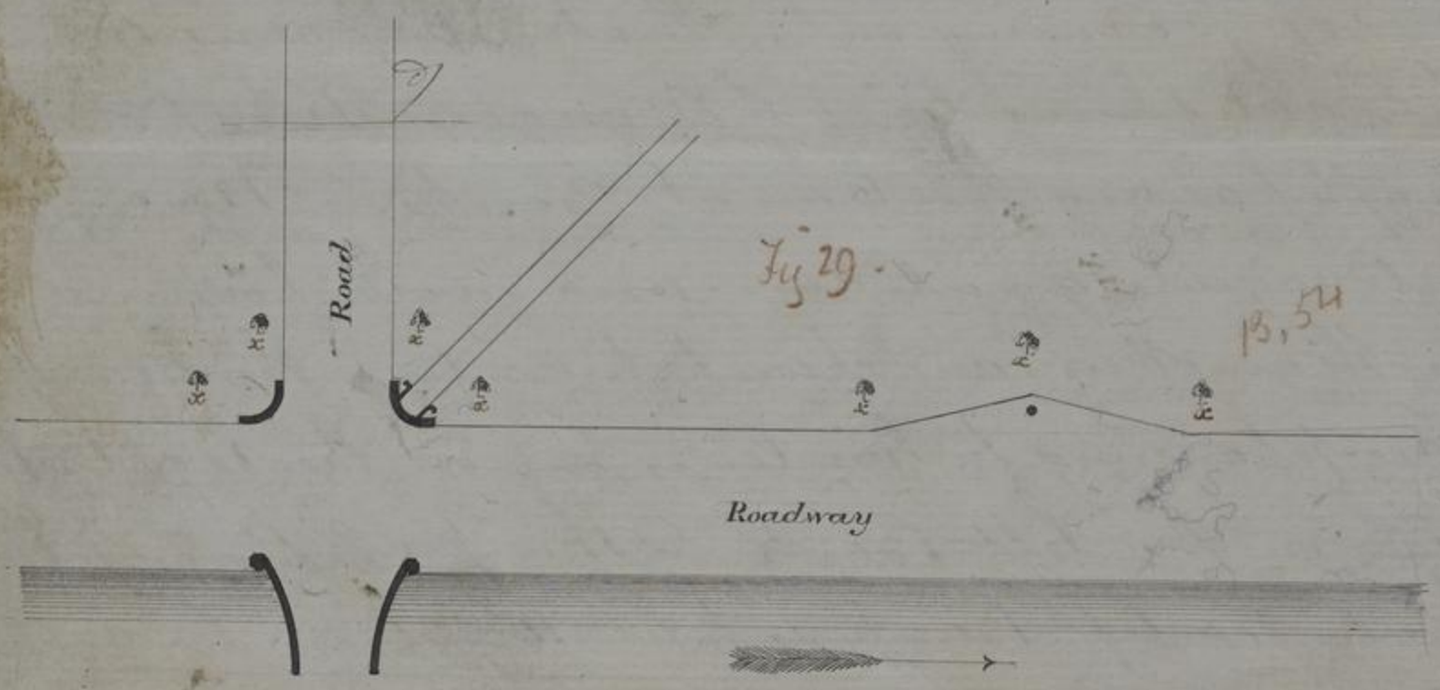
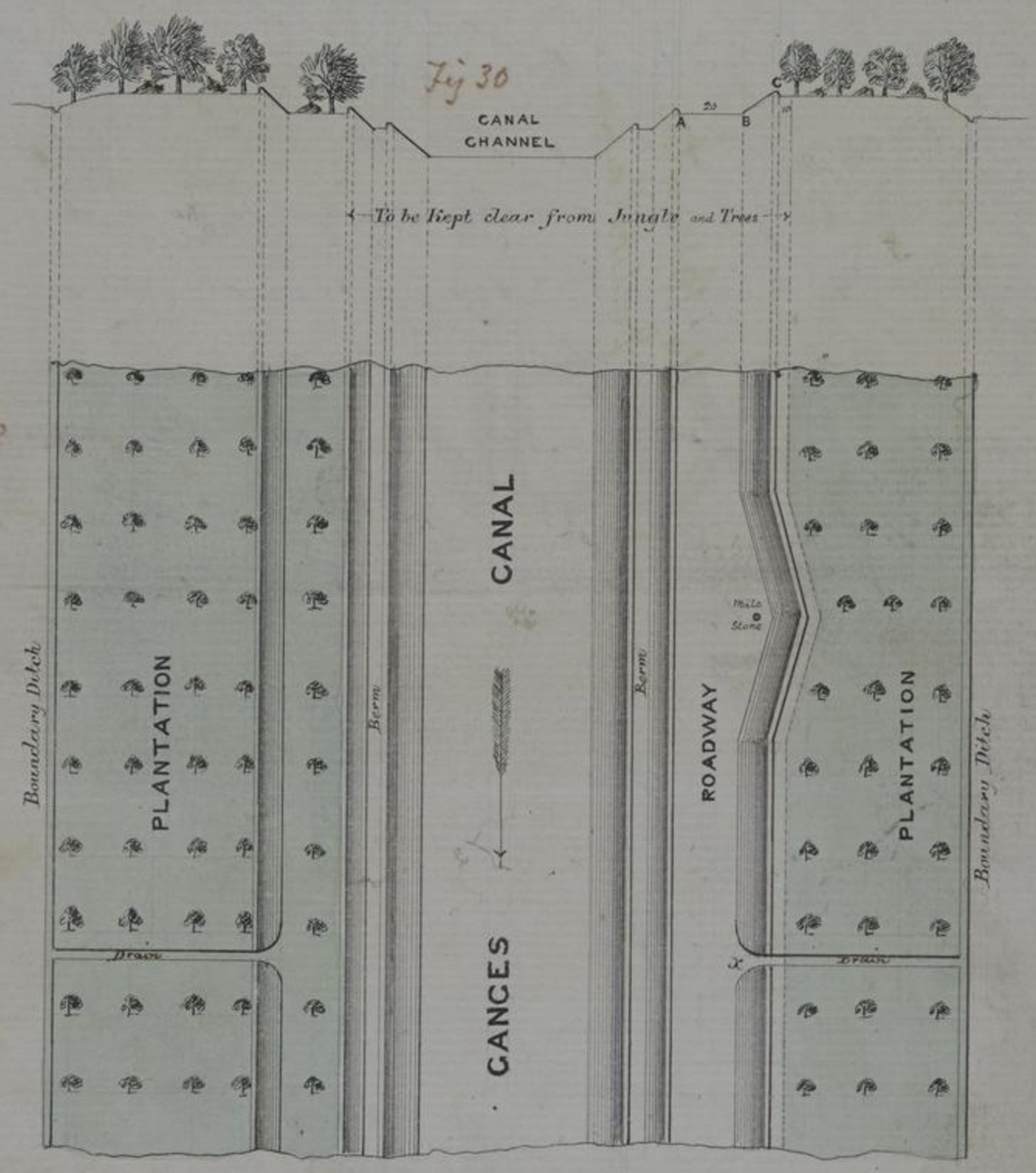


Fig 29.

13, 54

I shall be glad to hear of the arrange=
ments above described being entered on in
the ensuing season.

The following Diagrams will
show the lining out which I propose
for the Roadway and Plantations in those
places where the Section of the Canal
is thus:



The Roadway, which is to be 20
feet wide, is to have a slight slope exter=
nally from A to B so that the drainage may
be carried off at the foot of the slope BC to
drains, as shewn at x, which, being situated
at about 1,000 feet apart, will deliver the
water into the boundary ditches. I see

no

no necessity for going to heavy expenses in the Escapes; where kunkur is at hand they can be protected from injury by very simple arrangements, either by massive Blocks or by Concrete made with Kunkur gravel; where there is no material but brick, the refuse from Kilns, or broken brick which remains on hand after the completion of Bridges, may be used with great economy. But in many cases it is possible that no permanent structure may be required at all. Executive Engineers, however, will understand that I have no desire to go to heavy expense in their construction. The drains will be open through the Plantations, and not covered, and might be built of the following pattern.

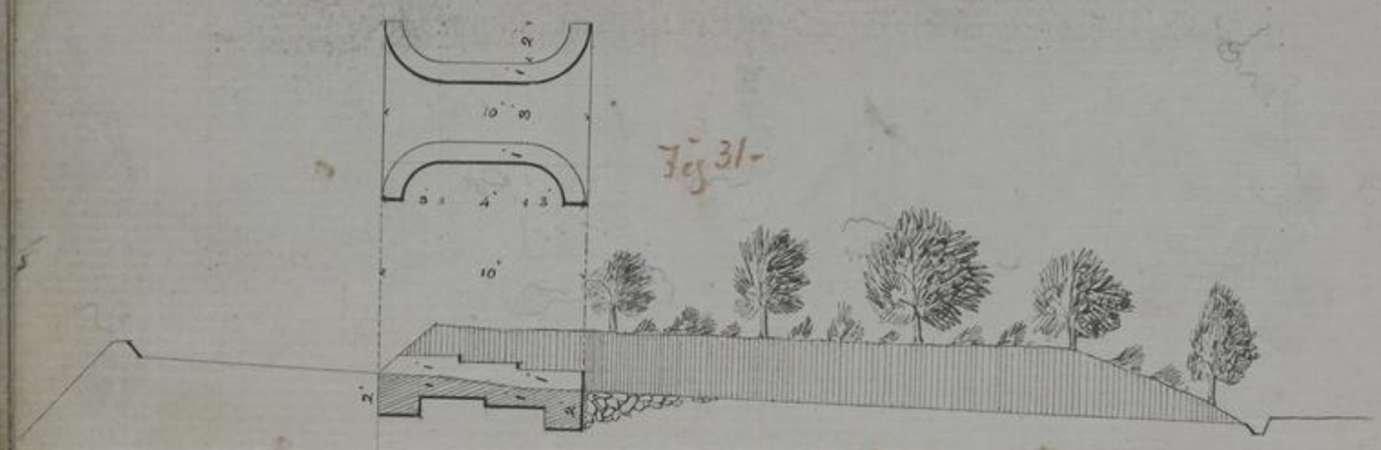


Fig 31-

B 54

/Signed/. P. T. Cautley. Lt. Colonel.
Director Ganges Canal Works.

APPENDIX

I

Comparative Statement of Details regarding Canal.

Name of Bridge.	Nos. of Arches radiating from one Centre, or from several Centres, according to Curves of Intrados.	Particulars as to Bricks generally used.	Workmanship equable throughout or not.	Mean Thickness of Joints.	Quantity of Materials in dry state, expended and Dimensions of Bricks. Lime.	Sand.	Bricks No. and dimensions.	Total Cubic feet of Masonry.	Keying performed in whose presence? Were Key bricks fitted into their places as tightly as possible by ordinary means? Any extraordinary means used? and, if so, of what description were they?	Precautions preparatory to Earthwork. How far was Earthwork in each Abutment completed at time centres struck, and was this Earthwork rammed and watered?
Kunkhuk.	From one Centre.	Particulars as to Bricks same as taken in preceding Cases.	Equable throughout.	From 3/16" to 5/16"	1050 C. feet.	2,100 do	None.	10306.6	One arch keyed in presence of Mr. W. Kay, and 2 under superintendence of a Mistree. Key bricks carefully dressed laid in fine mortar and driven with wooden mallets	Earthwork completed to about 3 feet below springs of arches; watered and rammed.
Savallapoor.	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Do.	Two Arches keyed in presence of Mr. W. Kay and one in presence of a Mistree only, with the same care as above detailed	Do Do. Do. below do. do do.
Lohumroora.	Do.	Do.	Do.	1/4"	1330 Cubic feet.	2,660 do.	None.	11,182.5.	Keyed in presence of Mr. Login. The keying was done in the same manner as described in keying the Mutheewur Bridge Arches.	Earth work with top of Arch 4 feet below top of Abutments; was then watered and rammed.
Veerakullaroo.	Do.	Do.	Do.	1/4"	1925 C. feet.	3,850 do.	None.	1,48,000 12"×5¾"×2½"	14,265.	Partly in presence of Mr. Parker and partly in presence of Ukbun Khan Mistree in the same way as the Mutheewur Bridges.	Up to within 3 feet from surface way. Earth well watered before commencement.
Moolaveen.	Do.	Do.	Do.	11/32"	1300 C. feet	2,600 do.	None.	1,47,1400 10"×5"×2¾"	12080.	Partly Keyed in presence of Captain Goodwyn and partly in presence of a Mistree. Previously to keying the Arches the layers on each side of the Key bricks were wedged back, the wedges being then taken out and the Key bricks tightly fitted in.	Earthwork completed to within 3 feet below springs of Arches and rammed.
Koorkee	Do.	Do.	Do.	0.28" or ¼" nearly.	1076 C. feet	2,152 do.	None.	7262 about 15"×7½"×3"	13,069.	Keying performed in presence of Mr. J. Login, Offg: Eng: & 1st officer, with exception of portion of one arch where greatest sinking subsequently occurred. Key bricks carefully dressed and laid - a pressure of about 1000 lbs obtained by use of a lever in addition to hammering and auxiliary to it being exerted.	Earthwork well watered and rammed completed to springs of Arches.
Mungaloor	From 5 Centres corresponding to curves of intrados.	Equable generally but many deviations in the Cattle Letter in favor of Arches.	Not ascertained.	Believed Do Do nearly correct.	1,648 C. feet	3296 do	None	Vide Arches 12"×6"×2" Ditto do 12"×6"×3"	13,734.	Keyed in presence of Lt: E. Fraser Dpo: Engineer; Key Bricks driven in with heavy sledge hammer, a piece of wood being interposed to prevent the Bricks splitting.	Earthwork completed to level below Crown of Arches; well watered and rammed.

onstruction of Arches of Bridges on the Ganges

1 6 8 8 3 3 3 3 10 8 7

Measures pre= Centres. Lowering and Removal of Centres and Results.

Earth or sand= weight haunches arches on the top were struck.	State of pro= gress of Wing and Span= dril Walls at time of lowering Centres.	After what intervals of time after key= ing were Centres first lowered.	Details of lowering Arches.	Ultimate Sinking of each of Three Arches. Centre. Left. Mean.	Did any cracks appear? If so, what were their position & dimen= sions, and was their direction parallel or perpendicular to Curve of Arch?	Did any crushing of Bricks take place and was this owing to inferi= or material or unequal pres= sure?	Did any Yielding of Abut= ments take place?
Filled with sand to haunches & left flat on crown of arches.	3 feet below crown of Arches	12 hours.	Centres lowered by equal areas= duration about ½ a ½" each.	2½" 3" 2½" 2.583" Quoted from Memory.	No cracks	No crushing	None.
Do do do	Level of cornice	2 days	Do Do	4" 5" 3½" 4.166" Quoted do do	Do.	Do.	Do.
Do do do	No Spandril or abutment walls to Level of Crown of Arch.	Began striking as soon as the last Key Brick was fixed, but the stri= king not completed till next day.	Began lowering the Centres ½ of an inch and afterwards ½ an inch at a time. This was continued till all the Centres were clear of the Arch.	.41' .36' .37' .38'	There were cracks not exceeding 1/32" broad along all the Arches, 5 feet above the Spring, but has the Spandril been filled with either Earth or masonry they could not have been seen, as I could not see them along the face of the Arches. The work being built and Centres struck all within 16 days may account for Arches sinking so much, the work being per= fectly green.	Do.	I did not think at the time that the abutments gave; but since then they ap= pear to have done so. The cause I think is that the block on which they rest has sunk.
Do	Do Spandril walls; Wing walls finished to full height.	12 hours	½ an inch at a time; Central part first haunches af= terwards.	.37' .21' .20' .27	No.	No.	No.
Up to 3 over the Spand= rils.	Do Spandril wall, Wing walls built to 3 feet below Crown of Arches.	After Arches haunches covered. After 24 hours all Key Bricks & Centres struck very quiet. Progress much hin= dered by rain then falling.	Centres lowered evenly at a time. Key Bricks first, Crown last.	.23' .21' .25' .23'	No.	No.	No.
Up to Springing.	Level with Springing of extrados.	Immediately.	Centres lowered ½ an inch at a time from Crown towards Springing, after 2 hours of the mean= time of Arches, after which the Centres were struck.	Keyed by Mistree 6.6" Down-stream 5½" Side Keyed by Mr. Logan. 5.52 5.14 5.753"	All slight cracks along the Crown of Arches.	No.	No.
4 feet below Crowns of Arches.	Level with Springing of extrados.	Immediately.	Centres lowered ½ an inch at a time towards Springing, after which the Centres were struck.	3.7" 3.7" 4.5" 3.96"	In the North face of the Eastern Arch in four Points were cracks of ½ an inch Eastern haunch the direction of which was parallel to curve being perpendicular to the Bridge Mark, from the masonry in the face being Lifted by the Arch.	No.	No.

Lebanhere	From one Centre.	But little dressing required.	Equable throughout	1/2"	1,316 C. feet	2,632 do.	None.	12" × 6" × 3"	11,529	Keying performed in presence of Mr. Conductor Gair and of Sergt. O'Farrell and superintended by Lieut. Fraser at intervals. Method of Keying the same as at the Mungleow Bridge.	Earth completed to level 4 feet below Crown of Arches, well watered and rammed.
Dimact.	Do.	Particular care taken.	Equable throughout	.3703 or 6/16 ths nearly	1,325 C. feet.	2,650 do.	None.	12 × 6 × 3"	11,529.	Keying of Eastern Arch performed by Mistree; of Centre and Western Arches in presence of Lt. Sharpe. Method of Keying the same as the foregoing.	Earthwork completed to top of wing walls prior to commencement lowering of Centre, both eastern & western Arches, but the Eastern Arch was 6 inches when the then backing of the abutment had attained the level of the springing line of the Eastern Curve.
Joghulsoor.	Do.	Particular care taken.	Equable throughout do.	.02"	1194 C. feet.	2388 do.	None.	1.16" × 5.04" × 2.40" = 6.9864 1.52" × 1.16" = 2.9664	11,529.	In that of Lt. Sharpe and Key bricks well fitted) were driven home by Sledge Hammers	Earth well watered & rammed to a height of 11 feet above springing of Arches.
Belra.	Do. Sig. V.R. 161 of I Vol.	Much dressing not required.	Do	0.25"	4030 C. feet.	2,015 do	None.	12" × 6" × 3"	11,529.	In that of Assistant Overseer Phillips. Key bricks dressed and driven in with heavy sledge hammers, a wooden wedge being interposed to prevent the brick from splitting. After keying fine mortar filled in over key bricks.	Do. Do. to 4 feet below Arches.
Pokeon	Do.	Do.	Do	From 4/16" to 5/16"	2662 C. ft.	1331 "	None.	68000 12" × 6" × 3"	10,773	Do. Do. Do.	Do. 10 Do. Do. 5 feet Do. Do.
Quilonee	Do.	Well dressed.	Do.	.23"	4,400 C. feet.	2200 do	None.	6000 = 12" × 6 2/3 No. of Native bricks 12" × 6" × 3"	10,828.	Do. Do. Do.	Do. Do. 2 feet Do. Do.
Sandut.	Do.	Do.	Do.	.24"	5,612 C. ft.	2096 "	None.	Do.	11,859	Do Do Asst: Overseer Dillon Do. Do.	Do. Do.
Surai.	Do.	3" Bricks dressed. Natives do not dressed.	Do.	1/5" nearly.	3906 C. ft.	1,953 "	None.	303.5 = 12" × 6 2/3 No. of Native bricks used in Centre	10,741/2	Do Do. Asst: Overseer Mills do. do.	Completed to 4 feet below Crown of Arches and rammed.
Whitesides	From 5 Centres corresponding to Curves of Entrances.	But little dressing	Generally so. but a little better in face of Arches.	1/4"	2,980 C. ft.	1,786 "	None.	12000 - 12" × 6" × 3"	15,773.64	2 Arches Keyed in presence of Mr. Read & Sergt Mills and by Sergt Mills: Key Bricks driven in as before	Well watered & rammed. Completed to level below Crown of Arches.
Sellores	From one Centre.	3" Bricks dressed. Native bricks not.	Equable throughout	1/5" nearly	4,244 C. ft.	2,122 "	None.	3030 - 12" × 6" × 3" No. of Native bricks used in Centre.	10,741/2	In presence of Sergt Mills. Key Bricks as before.	Earth rammed & completed to 4 feet below Arches.
Kheera	Do	Particular care Taken.	Do	3/16"	5176 C. ft.	2588 "	None.	4,400 - 12" × 6" × 3" Native bricks 6000 - 12" × 6 2/3 No. of Native bricks used in Centre	10,828	In presence of Sergt: Dillon. Do Do.	Earthwork built to Crown of Arches

	4 feet below Crowns of Arches.	Lowered one inch immediately after Keying.	Centres lowered 1/8 inch at a time from both sides towards centres of Arches, after intervals of one month after Keying.	1.2"	2.08"	1.44"	1.57"	No crack.	No.	No.
6	6	9	10	2	3	3	3	10	7	8
	Wing walls level with points of Arches. Crown of Arches 4 feet 9 inches below Crowns of Arches.	Do.	Do.	13"		15"		Many cracks parallel to the curves and perpendicular to it, both in faces & interior of Arches in the Middle; more particularly shewn at the haunches. Still resting on Centres in the middle.	Considerable crushing in the faces of Arches about the Crowns and haunches.	None.
	Both built to 11 feet above Spring of Arches.	Immediately.	They were lowered in the ordinary manner, from haunch to Crown" at a time to six days after keying.	1.19"	2.23"	1½"	1.64"	No.	No.	No.
	4' 6" below Crown of Arches.	Lowered one inch immediately.	Do as at Elsinore.	3.21"	3.26"	5.17"	3.88"	A few slight cracks on the Centre of Eastern Arch parallel to curve.	A slight crushing took place on North face of East Arch but not sufficiently to displace the faces of Bricks	No.
	7	7	10	2	3	2	3	11 A few cracks on each arch, parallel to curve, & scarcely perceptible.	7	7
	Do.	Do.	Do.	2¾"	2½"	3"	2¾"		No.	No.
	4 feet Do.	1 month.	Earthen Centres — Removed a month after Keying.	.06"	.04"	.03"	.04"	No.	No	No.
	Do.	Do.	Do.	.03"	.05"	.07"	.05"	No.	No.	No.
	Wing walls to level of inner Crown of Arches no masonry in Spandrils	2 months and six days.	Do: clear of Arches 2 mos & 2 6 days after Keying.					Very slight opening at haunches.	No.	No.
	2/4 feet below Crowns of Arches	2 months	Do. Do 2 mos & 10 days	½"	3/8"	¼"	3/8"	No.	No.	No.
No.	Wing walls to level of inner Crown of Arches.	2 mos and 1 day.	Do Do. 3 mos and 26 days					Very slight openings at haunches.	No.	No.
No	Wing walls 2 ft 6 below level of Crown of Arches Bases of Do.	Six months.	Do. Earth removed equably through out.	2¾"	2½"	3"	2¾"	A few cracks on each arch, parallel to curves but scarcely perceptible.	No.	No.

2	Nanoora.													Sir Graves.	
8 6	Do.	Do.	Do.	Do.	Do.	·1517"	3,100 C. feet.	1,350 "	None.	58.722.	105.780.	13.2"×6.6"×2.9"	7,337.3.	Do. Do.	To within a foot of crown of arch. remained and watered.
4	Do.	Do.	Do.	Do.	Do.	·175"	3,696 cubic feet.	do.	None.	105.780.	12.4"×6"×2.76"		15,939.	Do. Do.	To the level of top of Stewkabad spring of extrados or arch. well tered and rammed.
5	Do.	Do.	Do.	Do.	Do.	·1517"	3,696 cubic feet.	do.	None.	105.780.	12.4"×6"×2.76"		15,939.	Do. Do.	To within a foot of crown of arch. remained and watered.
7	Do.	Do.	Equable throughout.	3/16" to 5/16"	2,042 C. feet.	1021 do.	None.	65208.	2.6"×6.2"×17.52"		8951.	In that of Mr. Conductor Gain - Keying as before.		3 feet above spring of and do. do.	
9	Do.	Do.	Do.	1/4"	2,684 c.f.	1342 "	None	79,085.	12 1/2"×6 1/2"×2 3/4"		9803. 38	Do Do Do.		Earthwork completed to level Crown of arch principal sand, well rammed and watered.	
6	Do.	Do.	Do.	1/4"	2398 c.f.	1299 "	None	76,985.	12 1/2"×6 1/2"×2 3/4"		9803. 38	In that of Mr. Conductor Gain and Features Mixtures at intervals - Details as before.		Earthwork Complete to level of crown well rammed	
1	Do.	Do.	Do.	1/8" to 5/16"	3,087 c.f.	1,029 c.f.	None	79,580.	12.8"×6.3"×2.9"		9803.38	Do. Do. Do.		To crown of Arches. &c.	
7	Do.	But little care required.	Do.	1/4"	2,349 c.f.	783 "	None.	73,900.	Do.		8950.52.	Do Do Ramsook Mixtures - Do Do.		To 6 feet above ing arches. Do. Do.	
	Do.	Do.	Do.	1/8" to 1/4"	2,930 c.f.	Nona	None	75,000.	12"×6"×3"		9353.5	In that of Corporal Rao. Details as before.		To Springs hados - with mud & water	
	Do.	Do.	Do.	1/8" to 3/16"	3,000 c.f.	None	None	5,000. 12"×6"×3 6000. 12"×6"×2			9353.5	Do. Do.		Do.	
	Do.	Do.	Do.	1/8" to 1/4"	3,680 c.f.	None.	None.	88,600. 12"×6"×3"			12474.	Do. Do.		Do.	
	Do.	Do.	Do.	.24"	5,612 c	2096	None	Do.			11853	Do Do Asst: Overseer Dillon Do. Do.		Do. Do.	
	Do.	3" Bricks dressed. Natives do not dressed.	Do.	1/8" nearly.	3906 c.f.	1,953.	None.	303.5=12"×6"×3"			10714 1/2	Do Do Asst: Overseer Mills do. do.		Completed to 4 ft below springs of arches and rammed.	
	From 5 Courses corresponding to Curves of Extrados.	But little dressing	Generally so. but a little vellerin for arches.	1/4"	2,980 c.f.	1786 "	None.	12000-12"×6"×3"			15,715.84	2 Arches Keyed in presence of Mr. Read & Sergt Mills and 1 by Sergt Mills: Key Bricks driven in as before		Well worked and rammed. Completed level below springs of Arches	
	From one Centre.	3" Bricks dressed. Natives bricks not.	Equable throughout	1/3" nearly	4,244 c.f.	2122 "	None.	3050-12"×6"×3" 12000-12"×6"×3"			10714 1/2	In presence of Sergt Mills Key Bricks as before.		Earth rammed Completed to 3 ft below	
	Do	Particular care taken.	Do	3/16"	5176 c.f.	2588 "	None.	3000-12"×6"×3" 12000-12"×6"×3"			10828	In presence of Sergt: Dillon. Do Do.		Earthwork to crown of passage	

	Wing walls to 1 do. do. extrados - Spandils being 9½' do. do. extrados.	7	25 Days.	The Centres (Earthen) were first perforated by 3 Tunnels, one under crown 5' wide and at intervals of 7' by one on either side 7' wide, thus leaving 2 Earthen piers supporting the Arch. Leggings were then set to work 2 in the Centre Tunnels standing back to back and diverging outwards & towards the haunches) and the other 2 excavating the piers underhaunches likewise working outwards; as the piers lessened the Arch came down gradually pushing the earth and settling equably to its bearings.	3	3	3	3	11	7	8 16
	Wing walls level with intrados of crown & arches Spandrils none.	One Day	Do. Do.	·23	·22	·23	·226	A few bricks were found cracked on the face of the haunch of the last Arch, some days subsequent to final lowering of Centres,	Slightly at crown of each attributed to unequal settling.	No.		
Do.	Wing walls 3 above Spring of Arches. Spandrils walls not commenced.	2 months and 6 days.	In the same manner as at Sir Thomas but slightly retaining in with of Tunnels.	1½"	1½"	1½"	1½"	No.	No.	No.		
Do.	Wing walls to level of Cornice as well as outside wall Passages. No Spandril walls.	15 Days. Arches were clear of Centres in 10 days after.	Do.	1·½	1¼	1½	1 5/12	No.	No	No.		
Do.	Do.	2 Days. Arches clear in 15 days after.	Do.	1½"	1 3/4	2/4"	1⅓	No.	No.	No.		
Do.	Wing walls to level of Springs of Arches. No Spandrils.	Immediately. Centres were clear in 26 days.	Do.	1.2"	1"	1.2"	1.13"	No.	No.	No.		
Do.	Do 6 feet above Springing of Arches. No Spandrils.	Clear in 36 days after keying.	Do.	1.48"	1.5"	1.65"	1.55"	No.	No	No.		
Do.	Do to Spring of extra Dos.	1 month.	Do.	1.55"	1.5"	1.67"	1.54"	No.	No.	No.		
Do.	Do.	20 days.	Do.	1.6"	1.54"	1.5"	1.54"	No.	No.	No.		
Do.	Do.	2 months.	Do.	1.58"	1.53"	1.5"	1.52"	No.	No.	No.		

Nos.	Name.	Radius.	Splay.	Rise.	Quantity.	Quantity.	Quantity.	Quantity.	Quantity.	Quantity.	Remarks.	Remarks.	
6	Kirkoubee.	From one centre.	·16" to ·3"	3220 C.ft.	None.	None.	584.0 " 12"×6"×3"	760	In that of St: Merrick. Key Bricks driven in with wooden Mallets.	Abutments built against natural soil to Springing of Arch.			
5	Larchoo.	Do.	Do.	Do.	·14" to ·23"	2072 C.ft.	do.	do.	60.968 do.	do	Do.	Do.	
5	Allerfoon.	Do.	Do.	Do.	·063" to ·22"	2462 C.ft.	do.	do.	do. do.	do	Do.	Do.	
5	Sunnoch Loo.	Do.	Do.	Do.	·12" to ·28"	2636 C.ft.	do.	do.	61.908 do.	do	Do.	Do.	
8	Pulkhanna.	Do.	Do.	Do.	3/16" to 5/16"	2376 C.ft.	do.	do.	62.000 3/4 Arch 12"×6"×2½" 1/4 Arch 12"×6"×3"	7623	In that of Asst: Overseer Keer Virgins. Keyed as before.	Do within 2 feet of Abutt	
2	Drumkanna.	Do.	Do.	Do.	Do.	2330 C.ft.	do.	do.	61.500 12"×6"×3"	do.	Do.	Do Do on East side, on West side Abutt Spring of Arch	
3	Unnamed No:	Do.	No.	Do.	1/5" to 1/3"	3538 C.ft.	do.	do.	86.300 do	10,000	In that of the Executive Officer. Keyed as before.	Do Do Left below Spring of Arch, Centre 4 feet filled up & well watered.	
4	Kenmalloch	Do.	Do.	Do.	·24"	5612 c.f.	2096	None.	Do.	11853	Do Do Asst: Overseer Dillon Do. Do.	Do. Do.	
5	Knockmain.	Do.	3" Bricks dressed. Natives do not dressed.	Do.	1/5" nearly.	3906 c.f.	1953 "	None.	303.5=12"×6"×3" 1/5 of Natives Bricks used Abutments	10741/2	Do Do Asst: Overseer Mills do. do.	Completed below Springing of Arches and Centred.	
8	Whitestables	From 3 Centres corresponding to Curves of Entrados.	But little dressing	Generally so but a little below in face of Arches.	1/4"	2980 c.f.	1786 "	None.	122000-12"×6"×3"	15775.04	2 Arches Keyed in presence of Mr. Read & Sergt Mills and 1 by Sergt Mills: Key Bricks driven in as before	Well watered. Completed below Springing of Arches.	
5	Ruthven	From one centre.	3" Bricks dressed. Native bricks not.	Equable throughout	1/5" nearly	4244 c.f.	2122 "	None.	3030-12"×6"×3" Native bricks not. 1/5 of Natives used in Abutments	10741/2	In presence of Sergt Mills Key Bricks as before.	Earth Centre Completed to Grade below	
3	Unnamed	Do	Particular care taken.	Do	3/16"	6176 c.f.	2588 "	None.	4000-12"×6"×3" Native bricks 2000-12"×6"×3"	10828	In presence of Sergt: Dillon. Do Do.	Earthwork built to crown of Arch of passage	

Nos.	Not Commenced.	17 hours.	Centre portion removed at first time of striking & remaining portion electrical wates after	.17′	.17′	.17′	.17′	Slight Crack parallel to Arch about 2 feet from North face of Arch 20 feet long in Left and Centre Arches & 12 feet in right Arch	No.	No.
12.	1 Do.	1 Do.	1 Do.	.10′	.15′	.15′	.13′	No.	No.	No.
13.	1 Do.	1 Do.	1 Do.	.15′	.05′	.2′	.13′	No.	No.	No.
14.	1 Do.	1 Do.	1 Do.	.15′	.13′	.15′	.14′	No.	No.	No.
Inspection Wing Wall South of Branch 6 feet above Spring Arch.	Wing Walls South of 12 to 5 above spring of Arch. North Wing walls not commenced nor spandils.	24 hours	1 Do.	.17′	.2′	.2′	.19′	Slight Cracks appeared in Haunches before Keying but none after.	No.	No.
15.	1 Do.	1 Do.	1 Do	.15′	.125′	.125′	.13′	1 Do.	No.	No.
16.	Wings and Spandils not Commenced.	1 Do.	1 Do	.12′	.18′	.15′	.15′	Owing to work being Carried on in Wet rain The work of 2 Nos 1 The Arches had Also taken down The Cracks were so Considerable Prior to Keying None appeared after Keying of Arches.	No.	No.

Williamson.	6 Arch & Centre.	5 No.	4 Yes.	— ¼" to ⅓"	3 3114 Cubic ft	2 None.	1 None.	87.5.25 / 12"×6"×3	5 10,000.	In that of a Mistress. Keyed as before.	10 Natural soil to Spring of Arch.	
Mannion.	Do.	Yes	Yes.	.018"	1400 Rammers	do	do	60.5.60 do	7570.	In that of Lt Home. Keyed as before.	Carried up to a height of 5ft & well rammed & watered.	
Mountain.	Do.	Do	Do	.014"	1100 Rammers	do	do	do	do	Do	Do.	
Mountain.	Do.	Do	Do	.016"	1250 Rammers	do	do	do	do	Do.	Do.	
Anderson.	Do.	Do	Do	do	1150 Rammers	do	do	do	do	Do	Do	
Anderson.	Do	Do	Do	.0125"	896 Rammers	do	do	51.16.8 do	6396½	Do	To top of Spring both Arches. Well rammed & watered	
Burnside.	Do	Do	Do	.013"	967 Rammers	do	do	52.7.34 do	do	Do	Do.	
Burnside.	Do.	Do	Do	do.	1046 Rammers	do	do	54.5.18 do	do	Do	Do	
Masterson.	Do	Do	Do	.032"	1276 Rammers	do	do	44000 Bricks 800 Rammers	6933	In that of Lt Merrick Do Do Do	Not Commenced	
Sanders.	Do.	Do.	Do.	.24"	5612 c.f.	3906	2896	None.	Do.	11285	Do Do Asst: Overseer Dillon Do. Do.	Do. Do.
Mountain.	Do.	3" Bricks dressed. Natives do not dressed.	Do.	⅕ nearly.	3906 c.f.	1953 "	None.	30.5=12"×6"×3" 5% of Natives 1000=12"×6"×3"	10714½	Do Do Asst: Overseer Mills do. do.	Completed to 4ft below springs of arches and rammed.	
Mountain.	From 5 Centres corresponding to Curves of Extrados.	But little dressing	Generally so. but a little better in face of Arches.	1/2"	2980 c.f.	1786 "	None.	32000=12"×6"×3"	13715.84	2 Arches Keyed in presence of Mr Read & Sergt Mills and by Sergt Mills. Key Bricks driven in as before	Well worked & rammed. Completed to 4ft below Springs of Arches.	
Sutherland	From one Centre.	3" Bricks dressed. Natives bricks not.	Equally Straight out.	⅕ nearly	4244 c.f.	2122 "	None.	3600=12"×6"×3" N.B. 5% Natives 1000=12"×6"×3"	10714½	In presence of Sergt Mills Key Bricks as before.	Earth Rammed Completed to 4ft below Soffit	
Thorne	Do	Particular care Taken.	Do	3/16"	6176 c.f.	2588 "	None.	44000 Bricks 800 Rammers	10828	In presence of Sergt: Dillon. Do Do.	Earthwork Completed to Crown of Arches	

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7	—	—	10	3	—	—	—	11	7	7 10
No.	Not commenced.	24 hours	As before	·21	·17	·12	·16	Same as at Pukhana.	No.	No.
Spandrils Arch piers & face height & perpendicular Abutments.	Wing walls to 5 feet height above Spring of Arch. Spandrils Not Commenced.	2 days.	As at Satpara.	·25	·18	·18	·2	Small cracks about a knife's edge in thickness usually appeared in 3 layers after each had progressed 7 feet from springing. Always perpendicular to Curve.	No	No
Do.	Do do on upstream side on down stream side & level of Carriage. Spandrils do do.	do	Do	·1	·1	·15	·116	Do.	No	No
Do.	Same as at Mamun	do	Do	·25	·25	·25	·25	Do.	No	No
Do.	Same as at Achujan.	do	Do	·1	·1	·14	·113	Do	No	No
Piers Abutments Spandrils & Wing walls	Wing Walls to Top of Coping both ends.	Next morning	Do	·16	·16	·25	·19	No	No	No
Do	Do & Spring of do. do.	Do	Do	·16	·0	·08	·08	No	No	No
Do.	Do	Do	Do	·16	·05	·15	·12	No.	No	No
No.	Not Commenced.	14 hours	Rock Bricks on edge & Mortar dug through the Core of the Abutments	·2	·2	·2	·2	No	No	No

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Brick Arch.	Abutment	Same as Centre.	When Joint required.	Yes.	Yes.	.032"	1532 Brs.	None	None	64 680 12" × 6" × 3"	8223	As in the preceding Bridge.	Not commenced.
Do.	Wing Nº 1	Do.	Do.	Do.	Do.	do	149 Brs	do	do	43.000 do	6933	Do	Do.
Do.	Do Nº 2	Do.	Do.	Do.	Do.	do	1256 Brs	do	do	45.000 do	do	Do	Do
Do.	Do Nº 3	Do.	Do.	Do.	Do.	do	1066 Brs	do	do	37.600 do	8213	Do	Do
Do.	Do Nº 4	Do.	Do.	Do.	Do.	do	2650 C. feet	do	do	11.6"×3.8"×2½" 47.000 12"×6"×3"	5.545.125.	Keyed by Mistree with=out any Superinten=dence. Key bricks driven in by Malleh.	Level with Base of Arch; not rammed nor watered.
Do.	Do Nº 5	Do.	No	Do	7/16"		2650 C. feet	do	do	12"×6"×3" 43.700	5.068.125.	Under Lt: Dumbleton ditto ditto.	Do.
Do.	Do Nº 6	Do.	No	Do	Right 1/3" Centre Left 1/4"	Abutment & Pier Arches 20. Jan 1868 Centre Arch turned over 20 Feb 1868	2050 C feet	do	do	12"×6"×3" 43.800	5.068.125.	Do.	Do
Do.	Do Nº 7	Do.	No	Do	Right 3/10" Centre 2 Left 4/10"	Not quite.	2330 C. feet.	Do	Do.	12"×6"×3" 44.000 with Remained 12"×6"×2½"	5.545.125.	2 Arches in Presence of Ens: Engr: and Lieut: Dumbleton, the 3rd in presence of the latter. Key bricks as before.	Do
Sandstone	Do.	Do.	Do.	.24"			5.612 c.f.	3906 c.f.	2896	None	Do.	11.857	Do Do Asst: Overseer Dillon Do. Do.	Do. Do.
Granite	Do.	3" Bricks dressed. Natives do not dressed	Do.	1/5" nearly.			3906 c.f.	1953 "	None	None	303.5=12"×6"×3" 3" Natives and Bricks and Rubble	10.714.1/2	Do Do Asst: Overseer Mills do. do.	Completed below 1st below Arches and Dammed.
Whinstone	From 5 Centres, corresponding to Curves of Entrances.	But little dressing	Generally so but a little better in Jaws of Arches.	1/4"			2.980 c.f.	1786 "	None	12"×6"×3" 43.800 12"×6"×3" 22.000	15.715.24	2 Arches Keyed in presence of Mr Head & Sergt Mills and 1 by Sergt Miller. Key Bricks driven in as before	Well worked Dammed. Completed below 1st below Arches.
Sandstone	From one Centre.	3" Bricks dressed. Natives bricks not.	Equally throughout	1/5" nearly			4.244 c.f.	2122 "	None.	3000-12"×6"×3" Natives bricks not. 2000-12"×6"×2½"	10.714.1/2	In presence of Sergt Mills Key Bricks as before.	Earth Rammed Completed 1st below Arch
Whinstone	Do	Partially dressed	Do	3/16"			6176 c.f.	2588 "	None	24.000-12"×6"×3" Natives bricks not dressed 2000-12"×6"×2½"	10.828	In presence of Sergt: Dillon. Do Do.	Earth rammed to crown of Arch & Spandrils

No	Not commenced.	Right 38 hours Arch 14" Centre 22" Left 22"	As in the preceding.	·1′	·1′	·2′	·133′	No	No	No
No	Do	17 hours	do	·35′	·25′	·2′	·2166′	No	No	No
No	Do	14 hours	do	·3′	·3′	·3′	·3′	No	No	No
No	Do	Do.	do	·3′	·25′	·3′	·2833′	No	No	No
Cracks in the Soffit of the Arch.		3 days	Both being N. East. The wind during the Test - This period is from Casting to days.				Not accurately known Maximum 9"	Right Cracks from 6th to 16th Course up from Springing. do do 26th to 26th Course up Where slightest tendency to Splay is traceable.	No	No
Do		do	do				do 3/4"	Separation discernible here also but can hardly be called Cracks.	No	No
Do		do	do				do 9"	More decided here but still very slight and in some parts not traceable.	No	No
10 to 10 One Foot Headach, with do.		do	do				do 3/4"	None traceable in any joints tho' there were in the haunches, prior to Striking Cracks in the superincumbent Masonry.	No	No.

Sandakhurgun	Remarks Entire	Dressed but not radiated	Tolerably do.	3/8"	2,000 C.F.			12×6×3 12×6×2½	46000	5.5.45.12.5.	Under the Eye of Lt Dumbleton Key Bricks as before.	Earth level with crown of arches, but not rammed nor watered.	
Sunowlee	do	do	Yes	3/8"	1,580 C.F.			39.0660 12"×6"×2½"		5.09.2.0	In presence of Petumber Singh 1st asst Engr: Blocks of Kunkur carefully dressed 3" thick being driven in with blocks of stone 3 Arches keyed simultaneously.	None.	
Sunowlee.	do	do	Tolerably do.	1/4"	2,250 C.F.			12"×6"×2 7/8" 47,000		5.068.12.5	Under the Eye of Lt Dumbleton. Key bricks driven in with mallets.	Earth level with crown of arches. Not rammed nor watered.	
Sultanpoor.	do	do	Yes	3/8"	1,580 C.F.			43.818 12"×6"×2 7/8"		5.3.75.10	Same as at Sunowlee.	None.	
Bundio.	do	do	do	do	1,336 C.F.			33.936 12"×6"×2¾"		4.24.5.75.	Ditto.	Do.	
Guddumpoor.	do	do	do	do	1,368 C.F.			34.032 12"×6"×2¾"		4.31.2.12	Ditto.	Do.	
Gopalpoor.	do	do	do	do	1,320 C.F.			32.592 12"×6"×2¾"		4.15.1.4	Ditto.	Do	
Dhanoo	do	do	do	do	1280 C.F.			32.000 12"×6"×2¾"		4.03.3.7	Ditto	Do.	
Kaylai.	do	do	do	1/4"	1566 C.F.			37.152 12"×6"×2⅞		4.4.0.15.	In presence of Engr & Asst: Overseer: Keyed as before.	None.	
Sandu	Do.	Do.	Do.	.24"	5,612 C.F.	2896	None	Do.		11.85	Do Do Asst: Overseer Dillon Do. Do.	Do. Do.	
Surai.	Do.	3" Bricks dressed. Native do not dressed	Do.	1/5" nearly.	3906 C.F.	1,983 "	None.	303.5=12×6×3 1/5 of Native 2 Bricks & 1/5 of 3 Bricks &

...in the foregoing Bridges.		3 days	As in the foregoing Bridges.			Not accurately known	Slight separations visible at Skewbacks, but at no other places.	No	No	
None.	Wing walls built.	do	do			do	No	No	No	
...at ...lumpon ...l no ...ther ...es.		do	do			do	Separations at each Skewback; at left end of left arch being considerable, joint being thick; other separations very slight.	No	No	
None	Wing walls built.		do			do	a slight separation at one end & springing of right arch - and one in the same near the Crown.	No	No	
do	do Partly do		do	.03	.00	.015	.015	A do but distinct crack perceptible at springing right side of Centre Arch; very slight hair cracks might perhaps be perceived in all the haunches, but they were doubtful.	No	No
do	do		do	.025	.01	.03	.021	Very slight hair cracks perceptible for a time in all the haunches; most marked one in right side of right arch, as that a piece of paper might have been put in the but no more.	No	No
do	do Slight		do	.01	.00	.02	.01	None.	No	No.
do	do		do	.02	.01	.025	.017	No separation traceable in haunches, but slight cracks thro' parapets found above all the haunches.	No	No
None	Wing walls built	12 hours	do Cleared out in 4 days	.02	.03	.04	.03	Small cracks perceptible in haunches 2 & 3 ft above the springing. In the arches there are very minute ones, they extend up the face walls and parapets where they are traceable through to the extrados.	No	No.

| | | |

0	Wingwalls built.	12 hours	As in the preceding	.0′	.04′	.02′	.02′	Small cracks in haunches - in joints of masonry at just perceptible - do not appear in face walls and parapets.	No		16 No
7 do	Belly in face: twist facing walls built.	— Immediately	10 do 3 days	2 — .02′	— .0′	— .0′	— .01′	11 As before - but extended to face walls & parapets where they are wide enough to admit a trowel.	1 No		7 No
do	Part in Cement & part in Mortar Belging in face of Passages & Arches	do	do	.03′	.02′	.01′	.02′	do	No		No
do	do	do	do	.15′	.05′	.05′	.08′	do	No		No
do	Wingwalls built.	do	do 2 days	.03′	.02′	.002	.023	Minute Separations in Joints of all the haunches which have occasioned cracks in parapets.	No		No
do	do	do	do 3 days	.02′	.02′	.025′	.02′	Minute separations at first visible. but closed with superincumbent weight.	No		No
do	do	do	do	.03′	.03′	.02′	.026	do.	No		No
do	do Springing of passage Arches.	do	do	not accurately ascertained.			1/2″	do.	No		No
do	do.	do	do 6 days	.06′	.04′	.04′	.04′	do but not closed.	No		No
do	do 2 1/2 feet above do for a portion of their length	36 hours	do rapidly.	Not ascertained.				A very slight one across each at each haunches in joints - wide enough to admit a card.	No		No.

Invert.	Longitudinals	Ditto	Ditto	Ditto	1/4"	1300 c.f.			26030 12"×6"×2 3/4"	3291½		In presence of Lieut: Lamb - as before.	Ditto
	Keyhaven.	Ditto	Ditto	Ditto	1/8"	1444 c.f.			27653 - 12"×6"×2 3/8" 4789 - 9"×4½"×2 3/8"	3596½		Ditto	Ditto
	Kingsdon	Ditto	Ditto	Ditto	1/8"	1390 c.f.			27786 - 12"×6"×2 3/8" 7356 - 12"×6"×2 3/8"	3777		Ditto.	Ditto
	Sagaon.	Same as before	17 Yes	Diver in the place, Attended to.	1/4"	1422 c.f.				3777		Same as last.	N. A States.
	Longitudinals	Ditto	Ditto	Ditto	1/5"	1200 c.f.			26660 12"×6"×2 7/8"	3681		Ditto.	Ditto
	Rathkeale	178	Ditto	Ditto	1/5"	1100 c.f.			20560 12"×6"×2 7/8"	2759		Ditto.	Ditto
	Mungatown	Ditto	Ditto	Ditto	1/5"	1100 c.f.			23900 12"×6"×2 7/8"	2929½		Ditto	Ditto
	Longitudinals	Ditto	Ditto	Ditto	2/5"	1000 c.f.			21.900 12"×6"×2 7/8"	2759		In presence of Asst Overseer - as before.	Ditto
	Transverses.	Ditto	Ditto	Ditto	2/5"	1150 c.f.			22860 12"×6"×2 7/8" 10"×5"×2 3/8"	2830 2		Ditto	Ditto
	Sandstone	Ditto.	Ditto.	Ditto.	.24"	3612 c.f.	2896	None	Ditto.		11.85	Ditto Ditto Asst: Overseer Dillon Ditto. Ditto.	Ditto. Ditto.
	Limestone	Ditto.	3" Bricks dressed. Natives do not dressed.	Ditto.	1/5 nearly.	3906 c.f.	1953 "	None.	303.5 = 12"×6"×3		10.71.1½	Ditto Ditto. Asst: Overseer Mills do. do.	Completed about 4ft below crown of arches and Drawn made.
	Whitestones	From 5' Centres corresponding to curves of Entrances.	But little dressing	Generally on but a little below in face of arches.	1/4"	2980 c.f.	1786 "	None.	22000 - 12"×6"×3		13.75.0½	2 Arches Keyed in presence of Mr Read & Sergt Mills and 1 by Sergt Mills. Key Bricks driven in as before	Walk was 8 from mad. Completed about 4ft below crown of Arches.
	Settlers	From one Centre.	3" Bricks dressed. Natives bricks not.	Equally throughout	1/5 nearly	4244 c.f.	2122 "	None.	3050 - 12"×6"×3		10.71.1½	In presence of Sergt Mills Key Bricks as before.	Earth Commenced Completed to 4ft 6 feet below the Crown
	Thames	Ditto	Particulars not taken.	Ditto	3/16"	6176 c.f.	2588 "	None.	4400 - 12"×6"×3 Natives bricks not taken 1000 - 12"×6"×2 7/8" Natives bricks not taken.		10.62.8	In presence of Sergt: Dillon. Ditto Ditto.	Earthwork Complete to Crown of Arch of passage.

No	Same as in East	As in East	As in East	Not ascertained. Not perceptible with lines & rule	A slight crack in one haunch of right arch, do each do left do, & three joints 3 feet above the spring.	None	None
Do	Wing Walls not built	24 hrs	do	Do	One crack just perceptible 2 feet above spring at abutment end extending ½ way across arch.	do	do
Do	Wing walls to 2½ feet above spring of passage Arches for a portion of their length	do	do	Do	Slight separation in faces and extrados of Arches in each haunch 2 ft to 2¾ feet from spring.	do	do
Do	do	12 hrs	do	Do	Hair cracks in all haunches perpendicular to faces. Maximum depth 11" from extrados.	do	do
Do	Wing walls not built	do	do	Do	Do 13" Do	do	do
Do	Wing walls Canal Bd extrados of passage Arches.	do	do	.03'	Do in 3 do 6" Do	do	do
Do	Do	do	do	.01'	Do 2 do	do	do
Do	Wing walls not built.	do	do	did not exceed ½"	Do 3 do	do	do
Do	Do	do	do	Do	½"	Do	do	do

Thursday	Same as last	Yes	Same as last.	1/2"	880 c.f.	220 c.f. Bricks		17480 12" x 6" x 3"	2730		In presence of Asst. Overseer as before.		Not stated
Saturday	Do.	Do.	Do.	Do.	5612 c.f.	2896	None	Do.	11853		Do. Do. Asst: Overseer Dillon Do. Do.		Do. Do.
Monday	Do.	3" Bricks dressed. Natives do not dressed.	Do.	1/2" nearly.	3906 c.f.	1953 "	None.	303.5=12"x6"x3" 1/2 of Natives Bricks & Chunam	10714 1/2		Do. Do. Asst: Overseer Mills do. do.		Completed to level of Arches and dressed.
Tuesday	From 5 Centres corresponding to Curves of Entrances.	But little dressing	Generally so. but a little better in face of Arches.	1/2"	2980 c.f.	1786 "	None.	1/2 3000-12"x6"x3"	13715.5		2 Arches Keyed in presence of Mr. Read & Sergt Mills and by Sergt Mills. Key Bricks driven in as before		Work as usual & completed below crown of Arches.
Wednesday	From one Centre.	3" Bricks dressed. Natives bricks not.	Equable throughout	1/2" nearly	4,244 c.f.	2122 "	None.	3030-12"x6"x3" Natives bricks not 1/2 of Natives & Chunam.	10714 1/2		In presence of Sergt Mills Key Bricks as before.		Earth Chunamed Completed to level of Arch.
Friday	Do	Particular care taken.	Do	3/16"	6176 c.f.	2588 "	None.	3000-12"x6"x3" Natives bricks not 1/2 of Natives & Chunam.	10828		In presence of Sergt: Dillons. Do. Do.		Earthwork Completed to crown of Arch of passage.

No	Many walls heavily built	21 days	as before	Not ascertained	No	No	No	20
7	—	—	10	5	— — —	11	7	4

	Bindura	Mt Darwin	Mtoko	Mrewa	Rusape	Umtali	Salisbury	Hartley	Que Que	Gwelo	Selukwe	Gatooma	Umvuma	Fort Victoria	Enkeldoorn	Hunyani Poort	Marandellas	Macheke	Headlands	Inyazura	Mrewa	Mtoko	Mt Darwin	Bindura
	5	21																						
	5	4	–	–	3	–	–	1	5															

7	—	—	10	8	—	—	—	11		7	—

	at Barasso	Immediately	Completed in 6 days	011		0·08	0·95	No		No	No

23

Kutya	do	Yes	Liner in Jaces						13"+6"+3"				
Ustaspoor	do	do	do						do		As at Dao		None
Pilkuttoo	do	do	do						do		Lt. Brownlow: As before		None
Moorla	do												
Kreyoo	do												
Ollamana	do	do	do						9"×4½"×2" and 13"×6"×3"		Lt. Brownlow Asst. Engr. and Mistree West Arch. as before		Natural soil backing the Abutments.
Lonaree	do	do	Yes	.03' to .06'					13"×6"×3"		Asst: Overseer: As before		Level with Sheetbacking. Rammed but not watered.
Kulanda	do												
Seyoo	do	Yes	Yes	.02' to .03'					13"×6"×3"		As at Lonaree.		As at Lonaree
Sandee	Do.	Do.	Do.	.24"	5,612 c.f.	2096	None	Do.		11.85	Do Do Asst: Overseer Dillon Do. Do.		Do. Do.
Lonaree	Do.	3" Bricks dressed. Natives do not dressed.	Do.	⅓ nearly.	3906 c.f.	1953 "	None.	303.5=12"×6"×3" ½ of Natives Bricks 2"×6"×3"		10.74.1½	Do Do Asst: Overseer Mills do. do.		Completed to level of Arches and dressed.
Whitcombe	from 5' Centres corresponding to Curves of Entrances.	But little dressing	Generally so. but a little below in Jaces of Arches.	1/4"	2,980 c.f.	1786 "	None.	3200-12"×6"×3"		15.7.15.04	2 Arches keyed in presence of Mr. Read & Sergt Mills and 1 by Sergt Mills. Key Bricks driven in as before		Well watered & rammed. Completed to level below Crown of Arches.
Sutton	From one Centre.	3" Bricks dressed. Native bricks not.	Equable throughout	⅓ nearly	4,244 c.f.	2122 "	None.	3030-12"×6"×3" ½ Natives 1000-12"×6"×3"		10.74.1½	In presence of Sergt Mills Key Bricks as before.		Earth rammed Completed to level below Arch.
Kleine	Do	Particular care taken.	Do	3/16"	6176 c.f.	2588 "	None.	4200-12"×6"×3" Natives Bricks 1000-12"×6"×3"		10.82.8	In presence of Sergt: Dillon. Do Do.		Earthwork Completed to Crown of Arch of passage.

No		2 hours, 12 hrs after Injection and one extra Dose Diarrhoea	Ch at Londesboro		2"					
No		12 hrs	Do							
No										
No			a. at Londesboro							
do.		Doses Steam Mixed cases 12 hours after Injection No diarrhoea.	Commenced at 9	Sent Mem Bates Covered Animals Tuberculosis & Glands Omit to 30 Days	.05'	.06'	.05'	.053'	No	No	No
No			As at Londesboro							
No		Do at Londesboro Cattle ordered Per Ship.	Commenced at 9		.08'	.08'	.06'	.056'	No	No	No

Side of Cutting	Butter & Khan Kas Angles	Roadyards									
Side of Cutting		No	Yes	½"	26.500 13"×6½"×3¼"	L.315½	In presence of Engr & Asst Overseer & as before.	Natural soil up to 2½ feet below springing lines.			
Sandstone	Do.	Do.	Do.	·24"	5,612 c.f.	2096	None	Do.	11,855	Do Do Asst: Overseer Dillon Do. Do.	Do. Do.
Invert.	Do.	3" Bricks dressed. Natives do not dressed.	Do.	⅕" nearly.	3906 c.f.	1953.	None.	303.5=15"×6" 3% Natives with 6" set diagonally	10,714½	Do Do. Asst: Overseer Mills do. do.	Completed to Arch. 4 ft below springings of arches and cemented.
Abutments	From 5 Centres corresponding to curves of Extrados.	But little dressing	Generally so. but a little better in face of arches.	½"	2,980 c.f.	1786 "	None.	2200-12"×6"×3"	15,715·84	2 Arches Keyed in presence of Mr Read & Sergt Miles and Sergt Miles. Key Bricks driven in as before	Work worked & cemented. Completed to level below springs of Arches.
Abutments	From one Centre.	3" Bricks dressed. Natives bricks not.	Equable throughout	⅕" nearly	4,244 c.f.	2122 "	None.	3030-12"×6"×3" Nat. & Native bricks 12"×6"×3" alternately	10,714½	In presence of Sergt Mills. Key Bricks as before.	Earth Cemented Completed to 4 feet below roadway
Piers	Do	Particular care taken.	Do	3/16"	6176 c.f.	2588 "	None.	2400-12"×6"×3" Native bricks 12"×6"×3" alternately	10,82 8	In presence of Sergt: Dillon. Do Do.	Earthwork Complete to crown of arch of passage.

5	No	Wing walls & Curtain	12 hrs	As at Jno	1	1	1	Very fine hair Cracks from face to face at 10 ft. or 12 ft. Brick only visible at back of Arch. Cracks do in Centre Arch parallel to faces.	Do	Do.

APPENDIX
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Sandw.	Do.	Do.	Do.	.24"	5,612 c.f.	2896	None	Do.		11.85	Do Do Asst: Overseer Dillon Do. Do.	Do. Do.
Canal.	Do.	3" Bricks dressed. Natives do not dressed.	Do.	1/5 nearly.	3906 c.f.	1953.	None.	30 @ 5=12x6x3 2" Natives 30 @ 5=12x6x3 Natives		10.7½	Do Do Asst: Overseer Mills do. do.	Completed to level of arches and dammed.
Whitworths	from 5 Centres corresponding to Curves of Extrados.	But little dressing	Generally so but a little better in faces of arches.	1/2 "	2,980 c.f.	1786 "	None.	12000-12x6x3		15.7½	2 Arches Keyed in presence of Mr Read & Sergt Mills and by Sergt Mills. Key Bricks driven in as before	Well watered & dammed. Completed to level below Springs of Arches.
Tollins	From one Centre.	3" Bricks dressed. Natives bricks not.	Equable throughout	1/3 nearly	4,244 c.f.	2122 "	None.	3000-12x6x3 Natives 1000 " 12x6x3		10½	In presence of Sergt Mills Key Bricks as before.	Earth dammed. Completed to level below do.
Thomas	Do	Particulars not taken.	Do	3/16"	6176 c.f.	2588 "	None.	4000-12x6x3 Natives 1000 " 12x6x3		10.8	In presence of Sergt: Dillon. Do Do.	Earthwork Complete to crown of arch of passage.

APPENDIX

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Table exhibiting certain Statistics connected wi

1	2				3				4	5	Materia			
Name of Work	Distance of the Work from the Myapoor Regulator				Arches				Width of Roadway between Parapets	Measurement Content of Masonry	Bricks-			
	Miles	Furlong	Yards	feet	Number of	Span of	Height of Versed sine	Thickness at Crown	feet	Cubic feet	12"×6"×3"	12"×6"×2½"	12"×6"×2"	9"×4½"×3" Smaller sizes of various sizes
Head Works at Myapoor consisting of														
Dam on the Supply Branch of the Ganges River	Above Regulator													
Revetment connecting the Dam with the Regulating Bridge		D.												
Ghats. Bytukes, &c		D.								520101	–	36,4821	53574	– 98690
Myapoor Inlet		D.			1	20	4	1½	23					
Do Road Bridge		D.			1	20	4	1½						
Myapoor Regulating Bridge	0	0	0	0	10	20	4	1½	37½					
Do 1st Class Choki	0	0	73	2	–	–	–	–	–					
Sounda Seniwala Inlet	.	4	39	–	–	.	–	–	–	24694	–	62050	–	– 46555
Kunkhul Inlet & Outlet	1	2	213	–	.					43675	–	81790	–	– 8262
Kunkhul Mills..	–	–	–	–	–	–	–	–	–	–	–	–		
Kunkhul Bridge and Ghats	1	6	129	.	3	55	12	3	18	121683	–	320877	21582	– 22898
Sowalapoor Inlet	3	1	185	..	–	–	–	–	–	48929	–	149950	–	– 9346
Sowalapoor Bridge "Dalhousie Ghats" and Navigable Canal Head.	3	4	194	.	3	55	12	3	18	178961	–	734519	495	– 33276
Ranipoor 1st Class Choki	5	..	92	2	–	–	–	–	–	15917	–	146990		795

							These works are the perma-nent Regulators at the Head - A Dam over the Duffrey Branch is connected by a Revetment to the Regulating Bridge on the west Upstream of the Regulator - a massive Revetment connects the Myapore Inlet with the Main Works, and above the Inlet further Revetments with Extensive Ghats have been built - Behind these works and with the Road Esplanade between them extensive lines of Bylanes have been formed. The Choki is of the Standard Plan but Centre Room is 18ft -				1
0	—	98690	—	—	96991	—		90659	2	7	Lieut Strachey Lieut Yule Major Goodwyn
	—	4655	—	—	4565	—	This is a combination of Ghat and Drainage, to Inlet-water - a Block of Masonry having its upper fronting Steps'd for access to the water - with side Revetments to confine the Drainage as it passes over the Steps - The upper Step being on a level with the high water Mark	5628	2	8	Major Goodwyn
	—	8262	—	—	8070	—	These differ from the Lowndes Ghat-walls work in having Arched Passages - the Inlet has a 30 feet Passage - the Outlet 20 feet	8271	14	9	Lt Strachey and Major Goodwyn
Commenced		—	—	—	—	—	—	—	—	—	—
	—	22898	—	—	27734	—	Arches are Elliptical with Niches Pilasters - The foundations of this Bridge are 8 to 10 deep Ghats for approach of Bathers to the water are placed on all the flanks.	25853	6	3	Lt Yule and Major Goodwyn
	—	9346	—	—	9622	—	Same as Lowndes Ghat-walls but having a 100 feet Passage for drainage water -	8399	12	11	Major Goodwyn
	—	33276	—	—	35953		Bridge same as Kumkhul Foundations being 8'.. 6" deep - Ghats, similar to be built by the Marquess of Dalhousie, of 100 feet in length are placed on all 4 flanks - and the Head of the Navigable Channel passing by the Ramjoon works and Nubadeerabad Falls is situated on the upstream terminus of the Left hand up Stream Ghat -	39242	9	11	Lt Yule & Major Goodwyn
	—	795	—	—	780	—	Standard plan - the Centre room being 20 feet Square -	1895	12	7	Major Goodwyn

Ranipoor Superpassage and works - viz														
No 1 Fall on main Canal Superstructure to form Superpassage over Fall and No 1 Lock to pass Navigable Canal Irrigation Channel with Entrance Exit works	5	..	216	1	8 1 1	25 19 16	4 4 4	3 3 3	200	1636252	-	6213753	1500	
Bahadoorabad Store Room No 1.	-	-	-	-	-	-	-	-	-	3968	-	3125	35300	
Bahadoorabad mills	-	-	-	-	-	-	-	-	-	-	-	-	Only	
Bahadoorabad 1st Class Chokie	6	7	63	2	-	-	-	-	-	11749	-	-	119330	
Bahadoorabad Fall No 2.	6	7	163	2	8	25	5·5	2	28	421949	-	923500	728900	
Bahadoorabad Lock No 2.	do	do	do	do	-	-	-	-	-	83396	-	71043	11933	
Bahadoorabad Store Room No 2	-	-	1	1	-	-	-	-	-	3857	-	27596	-	
Bahadoorabad Fall No 3	7	3	182	1	8	25	5·5	2	18	428291	-	1431220	-	
Bahadoorabad Lock No 3.	do	do	do	do	-	-	-	-		81065	-	289100	27000	

Care Taken. 617 258 Ditto. 5000 Cubic Feet Wood. 18.8 Ditto. Ditto. Ditto. of passage.

						These works consist of an Aqueduct 200 feet in breadth between its pramports for the passage of the Ramipore Nullah, the Canal passing under this 8 arches of 25 feet Span each. On the up Stream a Fall of 9 feet is projected to carry the canal to a lower level. On the left of the Falls is a Locked Channel passing boats under the Superpassage. the Head of this Channel is situated at the Jowalapore Bridge On the left of the Lock Channel is another Channel for the supply of the Babandore and Mills. The Channels of Entrance and exit have their sides revetted with masonry on a considerable length.			
-	300294	-	-	298395	-		352088	2	8	Major Goodwyn
-	186	-	-	89	-	Same as the Centre Room of a 1st Class Clerk.	511	13	7	Major Goodwyn
Commenced		-	-	-		-	-	-	-	-
-	490	-	-	261	-	Standard Plan	1780	3	7	Major Goodwyn
10919 Chains	75310	-	-	71418	-	This Fall is 9 feet in Perpendicular Depth and its waterway is 200 feet in breadth at the Bridge which is thrown over the Head of the Fall	72788	8	11	Do
-	13952	-	-	16340	-	Same as No 1 of 9 feet The work consists of a Lock Channel and a waste one - with all the usual appurtenances of works of this kind	15807	3	2	Major Goodwyn
-	147	-	-	92	-	Same as No 1.	665	4	5	Do
7940 Chains	75993	-	-	77670	-	Same as No 2. Fall but having its Wing walls curved to suit a change in the direction of the Canal alignment	67613	10	3	Do
-	15302	-	-	14391	-	Same as No 2.	14701	5	2	Do

15 Tulempoor Inlet	8	1	163	2	-	-	-	-	-	35253	-	109413	-	
Puttri 1st Class Choke	9	4	161	-	-	-	-	-	-	14133	-	127608	-	
Puttri Superpassage and works viz'														
Note Fall in Main Canal														
" Lock in Navigable Canal	9	5	210	"	9	25	4	3	300	2243591	-	9411011	-	
Superstructure to form Superpassage over Fall and Lock with Entrance works -														
Badshahpoor Inlet	11	6	71	"	-	-	-	-	-	23763	-	75974	-	
Dhunowri 1st Class Choke	12	6	6	1	-	-	-	-		10190	-	101400	-	
Rutmood Works consisting of														
Roadway Bridge	12	6	73	:										
Inlet and outlet Dams	12	7	23	1						1496463	-	12134613	-	
Regulating Bridge with	13	"	109	1										
Revetments connecting the whole together														
Peeran Kulleem Bridge	14	2	133	2	3	55	737	3	18	1452144	-	756800	-	

Plan 100 Care taken. 190 110 617 258 200 Stone-Masonry 108 Gallons. Do Do. of passage.

						16	8			9	3
59	–	6836	–	–	7148	–	Same as the Lowndes Semi locks, but having a passage for Inlet drainage of 150 feet –	9193	2	2	Major Goodwyn
	–	704	–	–	577	–	Standard plan. the foundations being built on a series of Arches –	1759	2	2	Major Goodwyn
62	23218 Rham	28557	–	–	408945	80479	Same as the Rapid[illegible] works – but the Aqueduct has a water way of 300 feet – at the left side of this work, the Navigable Channel receives the main Canal – all the Falls having been passed –	437321	12	1	Do
74	–	3928	–	–	3967	2686	Similar to the Lowndes Semi locks – but in consequence of the nature of the Soil having its foundations sunk by means of wells –	8283	13	8	Do
00	–	374	–	–	370	–	Standard plan –	11421	12	4	Do
63	26962 Rham	208981	–	–	397905	6058	On the approach to the site of these works there is a sudden curve in the Canal alignment to bring it on a direct bearing with the Solano Aqueduct locks This Curve is revetted on either side with Masonry until it meets the Straight alignment, at which point a Bridge for communicating Spans the Canal – from this Bridge further Revetments line both sides of the Canal until a junction is formed with the Inlet on the Right and outlet on the left of both of which works have clear waterways of 800 feet for the Passage of the Tow Boats – Also these works additional Revetments meet a Regulating Bridge, the down stream of which is finished off with Chats	522231	2	1	D.
	–	1742	–	–	34892	–	This Bridge differs from the foregoing ones in having its Arches Segmental instead of Elliptical – and in the height of Roadway being 36 ft but from the Flooring of the bays instead of 24 ft Passages for the towing Paths are pierced in the abutments these planks being rustic and works to the same height as the piers with which they correspond –	35307	14	..	Major Goodwyn

for the accommodation of Boatmen –

Solani Aqueducts Works consisting of															
Mahewun Bridge	15	7	150	..	3	55	12	3	18						
Aqueduct Propsl	18	..	134	2	15	50	8	5	—						
Roorkee Bridge	18	5	169	1	3	55	12	3	18						
Earthen Aqueduct with Masonry Revetted sides connecting the whole of the above works together. above the Mahewun Bridge an Ogee and Cattle Ghats with Escapes. Below the Roorkee Bridge there are similar Ogee Cattle Ghats with a Revetment protecting the Right bank on the whole length of the Roorkee Canal —													107,5,4,218	15080	82,76,338 388,809
Roorkee Workshops - - - - - - - - - -													571329 not complete	—	3132057 —
194 Directors Office - - - - - - - - - -													11223	—	10877 —
Government accommodation Bungalow - - - - - - - - - -													220597	—	157977 —
Hospital - - - - - - - - - -													principally		Kutcha
Mr Parkers Bungalow - - - - - - - - - -														—	20000 —
Burial ground - - - - - - - - - -													5645		48480 —
Guneshpoor Bridge	20	.	24	2	3	55	12	3	18				7832 not complete	—	112600 —
Asso Snuggur 1st Class Choki	22	4	216	2	-	-	-	-	-				12088	—	— 124004 —

Kutcha Pucca Cart Road taken. 330 110 617 258 Good Stations 108 Bullocks. Do Do. Partly Do.

						The Commencement of these works are Escapes on the Right Theft of the Canal which if required can be used as safety valves - these Escapes are followed by Cattle Sheds for the approach of Cattle to the Canal water - From these Sheds the Revetments of the Eastern Aqueduct commence they meet the Makeewan Bridge in Ogee Curves and leave it similarly they are then carried in a direct line till their approach to the Aqueduct proper - the Canal passes thro' the Aqueduct proper in 2 Chambers - and the Trench passes under the Canal in 15 Arches of 50 feet Span each - Below the Aqueduct proper and above and below the Rookee Bridge the Revetments & Works correspond in all respects with them on the Makeewan side except that there are no Escapes - the right bank of the Canal below the Aqueduct Terminus is revetted on the whole length of the Curve which the Canal takes at this point	8				
17	587005 Shamsabad & Kunkhul	176588	-	-	21.12802			3286812	10	9	Lieut Thackery Dr Gale, and Major Goodwyn
	24597 Shamsabad	40136	-	-	44218	-	These Buildings contain separate accommodation for Writers, Constables &c - and the Commencement of a Town by the erection of numerous Shops Rooms - Engine Rooms - &c &c	85745	.	2	Dr Trumbull - Dr Gale & Major Goodwyn
	-	2133	-	-	1827	-	a Centre Room 36' x 20' with a 10 feet Verandah all round - the North and West ends being formed into Rooms -	5307	14	5	Major Goodwyn
	568 Shamsabad	1356	-	-	550	-	2 Rooms 20' Square each surrounded by a Verandah the North and South ends of which are inclosed as sleeping Rooms & Baths - Roof thatched -	3441	7	10	Do
	-	-	-	-	-	-	a plain room with a Verandah round it and thatched roof	1286	1	7	Dr Thackery
	-	120	-	-	120	-	———	1008	10	6	Major Goodwyn
	-	582	-	-	692	-	merely a plain Wall	735	5	11	Do
	15520 Shamsabad	10489	-	-	21744	1884	Same as Kunkhul. but with a different form of Plan -	17738	8	6	Major Goodwyn and Dr Fraser
	-	663	-	-	884	-	Standard Plan -	2357	10	4	Major Goodwyn

15															
Assofnuggur Navigable Channel Head Works and Right Rajbaha Head		2½	2½	2	–	– – – – –			3	5	68975	–	73050	–	
Assofnuggur Falls		22	5	196	2	8	25	5	2	18	421913	–	3457766	–	
Assofnuggur Locks, Mills and Left Rajbaha Head		do	do	do	do	3	(2 of 10' 1 of 15')			15	57486 (not complete	–	430967	–	
Munglour 2d Class Choki		24	5	194	..	–	– – – –			–	4577	4	34327	4	
Munglour Bridge and Ghats on both up and down stream		24	6	94	2	3	55	12	3	18	126096	4	945720	4	
Silburheri 2d Class Choki		26	1	80	..	–	– – – –			–	2576	1920	–	–	
Silburheri Bridge and Ghats		26	1	189	1	3	55	12	3	18	139954	4	1049655	4	
Mundowli Bridge		28	5	124	,	3	55	not yet complete		21	59542	4	446565	4	
Mymoodpoor navigable channel Head and Right Rajbaha Head		30	3	100	..	–	– – – –			–	56997	4	427477	4	
Mymoodpoor 1st Class Choki		30	7	182	2	–	– – – –			–	14316	4	107370	4	
Mymoodpoor Locks Mills and Left Rajbaha Head.		31	–	97	1	3	(2 of 10' 1 of 15')			15	127044	4	952830	4	
Mymoodpoor Falls		31	–	144	2	8	25	55	2	18	451597	4	3386977	4	
Dimat Bridge with Ghats		33	5	93	1	3	55	12	3	18	135719	4	1017892	4	
Joghulpoor 2nd Class Choki		38	..	57	.	–	– – – –			–	2488	4	13215	4	

Taken. Taken. Taken.

						16	8		9	5	
13625	Ihana	13223	–	–	20140	–	These Consist of a Block of Masonry built into the Bank of the Canal at the point of deposition of the Channel - Inside forming the left Revetment on the Main Canal the other the Right of the Navigable one - Opposite these Revetments are others lining the sides of the 2 Canals & the Rajbuha Road is in connection with the upstream ends of the main canal Right Revetment	17523	14	2	Major Goodwyn & Lt Fraser
6250	Ihana	65860	–	–	85735	–	Similar to the No 2 Bahadoorabad Falls – except in foundations which are greatly increased to meet the altered soil that is here met with –	91419	..	6	Major Goodwyn
2900	Ihana	6800	–	–	10362	504	Similar to those at Bahadoorabad – but has a Mud House and a Rajbuha Road appended	not complete			Major Goodwyn and Lt Fraser
–		763	–	–	1525	–	a One room'd House 20' × 20' with a door to the front and rear – all pukka	757	9	11	Mr J Read –
		21016	–	–	42032	–	Foundations 12' to 13'. 3" below Canal bed – Ghats of 25 feet length on each flank the whole being protected by piling and Bar work Towing path rests on wooden frame work –	24131	3	..	Lt Turnbull and Lt Fraser of the Engineers – and Mr J Read –
–		429	–	–	858	–	One Room 18' × 14' Kutcha Pukka	304	10	10	Lt Turnbull
–		23326	–	–	46651	–	Foundations 11·67' below Canal Bed. 25 feet Ghats on down Streams. Protected as at Munglowe	23577	4	8½	Lt Fraser and Mr J Read.
–		9924	–	–	19847	–	will be the same as the Munglowe Bridge – but without Ghats. Foundations 15 feet below Canalbed –	12897	11	11	Mr Read
–		9500	–	–	19098	–	Similar and for the same objects – as the same kind of works at Assofnuggur –	10996	15	1	Mr Read
–		2386	–	–	4772	–	Same as at Assofnuggur	24122	14	6	Mr Read
–		21174	–	–	42348	–	Same as at Assofnuggur	23960	14	9	Mr J Read
–		75266	–	–	150532	–	Same as at Assofnuggur	80496	5	8½	Lieut E Fraser and Mr Read
–		22620	–	–	45239	–	Same as at Siburheri Foundations 15 feet deep –	25715	7	10	Do
–		294	–	–	587	–	Same as at Siburheri	276	11	2	Mr J Read.

Joghulpoor Bridge	38	.	149	1	3	55	12	3	18	112690	845175	~	~	
Bairha Navigable Channel Head and Right Rajbuha	41	6	138	2	1	10	5	2	–	57164	428730	~	~	
Bairha 2nd Class Choki	42	3	80	1	–	–	–	–	–	3068	23010	~	~	
Bairha Locks, Mills and Left Rajbuha Head	42	3	138	–	3	(2 @ 10', 1 @ 15')			15	126675	950062	~	~	
Bairha Falls	42	3	185	1	8	25	55	2	18	396370	~	~	2972775	
Bairha 1st Class Choki	44	.	153	:	–	–	–	–	–	10225	76687	~	~	
Bairha Bridge	44	1	41	1	3	55	12	3	18	112931	846982	~	~	
Bhojpah 2nd Class Choki	46	3	177	2	–	–	–	–	–	2404	18030	–	–	
Bhojpah Bridge	46	4	44	.	3	55	12	3	18	109543	821572	~	~	
Jowli Navigable Channel Head & Right Rajbuha	47	4	204	–	1	10	5	2	–	45575	341812	~	~	
Jowli Falls	48	2	11	2	8	25	55	2	18	367130	2753475	~	~	
Jowli Locks, Mills and Left Rajbuha Head	48	2	26	..	3	(2 @ 10', 1 @ 15')			15	131506	986295	~	~	
Kuttigurh Branch Head Regulating Bridge	50	2	205	2	4	20	6	1·5	18					
Ghats & Platforms connecting above with	50	3	48	.	–	–	–	–	–	136046	1020345	~	~	
Jowli Main Canal Regulating Bridge	50	3	81	.	9	20	6	1·5	18					
Jowli 1st Class Choki	50	4	22	..	–	–	–	–	–	13998	–	104985	–	
Dukheri 2nd Class Choki	53	2	102	2	–	–	–	–	–	2928	.	21960	–	
Dukheri Bridge	53	3	16	–	3	55	10	2¾	18	91199	~	683992		
Jansut 2nd Class Choki	54	4	195	–	–	–	–	–	–	2928	21960	–	–	
Jansut Bridge and Ghats	54	5	108	2	3	55	10	2¾	20	146655	~	1099912		
Chitowra Navigable Channel Head & Right Rajbuha Head	55	1	182	1	1	10	5	2	–	56161	~	421207		
Chitowra 1st Class Choki	55	6	134	2	–	–	–	–	–	15547	~	116602		
Chitowra Locks, Mills, & Left Rajbuha Head	55	6	182	.	3	(2 @ 10', 1 @ 15')			15	141537	~	1061527		

						Set				
–	18782	–	–	37563	–	Same as Munglow Bridge but without Sluts – Foundations from 10'3 to 16' depth	22710	8	5	Lieuts Turnbull & Fraser & Mr Read.
–	–	–	19054	9528	–	Same as at My moodpoor	10601	13	10	Mr F. Read –
–	–	–	1023	511	–	Same as Libunheri	275	14	2	Lt Turnbull
–	–	–	42225	21112	–	Same as My moodpoor	18109	14	10	Mr F Read
–	–	–	132123	66062	–	Same as at My moodpoor except that Tail Sluices are curved outwards instead of inwards. –	77523	3	9	Lt Fraser & Mr Read
–	–	–	3408	1704	–	Standard plan	1184	9	11	Lt Turnbull & Fraser
–	–	–	37643	18822	–	Same as Joghulpoor Foundations 15½' depth	21662	11	3	Lt. Turnbull & Fraser and Mr Read –
–	–	–	802	401	–	Same as Libunheri	235	10	6	Lt Turnbull and Fraser –
–	–	–	36514	18257	–	Same as Joghulpoor Foundations 15' depth	21760	12	3	Lt Fraser and Mr Read –
–	–	–	15191	7695	–	Same as My moodpoor	8964	3	3	Mr F Read
–	–	–	122377	61188	–	Do	61368	11	10½	Lieuts Fraser and Mr Read –
–	–	–	43835	21918	–	Do	21927	1	8	Mr Read. –
–	–	–	45349	22674	–	These works are situated at the point of departure of the Tultetgunge Branch Canal.	29770	14	3	Lt Fraser and Mr Read
–	–	–	4666	2333	–	Stand and plan	1328	13	1	Do –
–	–	–	976	488	–	Same as Libunheri	2574	12	9	Do
–	–	–	30398	15199	–	This Bridge has a segmental arch with a versed sine of 10' – Its Spandrils are perforated to assist lightness Foundations 10'25' depth –	16366	8	7	Do
–	–	–	976	488	–	same as at Libunheri	2644	13	5	Do.
–	–	–	48885	24442	–	Same as at Dukheri – but with Sluices on down stream – Foundations 10' depth	25843	12	3	Do –
–	–	–	18720	9360		Same as at My moodpoor	10827	–	2	Mr F Read
–	–	–	5182	2591		Do	2749	15	4	Do
–	–	–	47178	23589		Do	18153	11	8	Do

15	2½	2½	2	-	-	-	-	-	1	5	-	-	-
Chitowra Falls	55	7	9	1	8	25	5·5	2	18	316995	〃	2377472
Serai 2nd Class Choki	58	4	177	2	.	-	-	-	-	2928	〃	21960
Serai Bridge	58	5	90	.	3	55	10	2·75	18	89602	〃	672015
Khutowli Bridge and Ghats	62	1	67	1	3	55	12·3		24	159520	〃	1196550
Khutowli Escape	62	2	42	.	10	6	1·5	1·5	8½	57849	〃	433867
Sutheri 2nd Class Choki	64	3	143	-	-	-	-	-	-	2928	〃	21960
Sutheri Bridge	64	4	61	2	3	55	10	2·75	18	123114	〃	923355
Sullawur Navigable Channel Head and Right Rajbaha Head	66	5	141	2	1	10	5	2	-	45658	〃	342434
Sullawur 1st Class Choki	67	2	101	2	-	-	-	-	-	12602	〃	94516
Sullawur Locks, Mills & Rajbaha Head (Left)	67	2	144	1	3	(2·7	10'	1·7	1·5)	15	116233	〃	871747
Sullawur Falls	67	2	191	2	6	25	5·5	2	18	325368	〃	2440260
Aboo's Mulla Escape	69	6	213	1	10	6	1·5	1·5	8½	56752	〃	425640
Aternah 2nd Class Choki	71	2	93	.	-	-	-	-	-	2761	〃	20707
Aternah Bridge	71	3	6	2	3	55	10	2·75	18	74142	〃	556065
Sirdhanna Bridge and Ghats	74	5	46	.	3	55	12·3		25	165018	..	1237635
Sirdhanna 1st Class Choki	74	6	199	1	-	-	-	-	-	12602	〃	94515
Nanoo 2nd Class Choki	77	4	93	1	-	-	-	-	-	2928	—	21960
Nanoo Bridge	77	4	192	2	3	50	7	2½	25	123243	-	924322
Sutpoora 2nd Class Choki	79	7	73	-	-	-	-	-	-	2928	〃	21960

						16	8			9	7	
–	–	–	105664	52832	–	Same as at Mymoodpore	55132	13	5	Lt Fraser and Mr Read –		
–	–	–	976	488	–	Same as at Libenhein	276	12	6	Do		
–	–	–	29868	14933	–	Same as at Dukhein Foundations 10' deepr. –	16527	2	..	Do		
–	–	–	53180	26590	–	Similar to Mungloor Bridge except that it has longer Ghats – and passages through the abutments for the Towing Path – Foundations 12'	27529	6	10	Do		
–	–	–	19283	9641	–	Situated on the Right Bank of the Canal – and forms the Head of an Escape Channel which empties itself into the River Hindun	11778	2	9	Do. –		
–	–	–	976	488	–	Same as at Libenhein	241	5	8	Do.		
–	–	–	41038	20519	–	Same as at Dukhein Foundations 11'25'	20889	7	.	Do		
–	–	–	15219	6246	–	Same as Mymoodpore	9349	9	1	Mr J Read		
–	–	–	4201	2100	–	Standard Plan	1189	14	8	Lt. Fraser and Mr Read.		
–	–	–	38744	19372	–	Same as at Mymoodpore	13443	6	2	Mr J Read		
–	–	–	108456	54228	–	Do but water way contracted to 150' –	57885	–	9	Lt Fraser and Mr Read –		
–	–	–	18918	9459	–	Similar to that at Khutowli – but without covered way –	10487	11	7	Mr J Read		
–	–	–	920	460	–	Same as at Libenhein	281	7	11	Do.		
–	–	–	24714	12357	–	Same as Dukhein Foundations 7½'	16711	13	1	Do –		
–	–	–	55006	27503	–	Similar to Khutowli Bridge Foundations 6⅔'	31571	12	..	Lt Fraser and Mr Read		
–	–	–	4200	2100	–	Standard plan	1176	1	10	Do		
–	–	–	976	488	–	Do	274	6	6	Do		
–	–	–	41080	20520	–	Here the width of Bridge is reduced to 150' in 3 Bays of 50' each – the Arch is a segment with 7' versed rise – The Spandrils have a circular hole pierced through them. Ghats are provided on each Flank – Foundations 9'	20229	14	5	Do.		
–	–	–	976	488		Standard plan	275	2	11	Do		

Jutpoora ℣Bridge	79	7	168	-	3	50	7	2½	18	73300	—	+	54	9750
Pooth 2nd Class Choki	82	2	161	1	-	-	-	-	-	339	—	+	2	5455
Pooth ℣Bridge	82	3	38	-	3	50	7	2½	20	8518	—	+	6	0635
℣Bhola navigable Channel Head and Right Rajbuha Head	83	4	206	1	1	10	5	2	-	63822	—	+	47	8664
℣Bhola 1st Class Choki	84	1	183	2	-	-	-	-	-	12602	—	+	9	575
℣Bhola Locks Mills Left Rajbuha Head	84	2	6	1	3	(2	9	10;	1	8 15)	15	1[illegible]	—	+	1	05830
℣Bhola Falls	84	2	53	2	6	25	5	5	2	18	331105	—	+	21	83287
Sanni Escape	87	..	134	..	10	6	1	5	1	5	8½	6968	—	+	5	21010
Sanni 2nd Class Choki	87	..	153	2	-	-	-	-	-	-	3033	—	+	2	2747
Sanni ℣Bridge	87	2	71	..	3	50	7	2½	20	78061	—	+	5	85457
Nugla 2nd Class Choki	89	5	55	..	-	-	-	-	-	-	3313	—	+	2	847
Nugla ℣Bridge	89	5	151	..	3	50	7	2½	20	77016	—	+	5	77620
Newarri 1st Class Choki	93	2	65	1	.	-	-	-	-	-	14112	—	+	1	05840
Newarri ℣Bridge	93	2	217	..	3	50	7	2½	18	71088	—	+	5	33160
Soundha 2nd Class Choki	96	1	41	1	-	-	-	-	-	-	3200	—	+	2	4000
Soundha ℣Bridge	96	1	151	1	3	50	7	2½	18	71215	—	+	5	34112
Aboopoor 2nd Class Choki	98	3	35	2	-	-	-	-	-	-	3128	—	+	2	3460
Aboopoor ℣Bridge	98	3	140	1	3	50	7	2½	18	71043	—	+	5	32822
Moradnuggur 2nd Class Choki	100	1	104	-	-	-	-	-	-	-	3128	—	+	2	3460
Moradnuggur 13 Bridge & Shuts	100	1	208	1	3	50	7	2½	25	144034	—	+	10	80255
Noorpoor 2nd Class Choki	102	7	203	1	-	-	-	-	-	-	3173	—	+	2	3797

–	–	–	24436	12213	–	Same as at Narrow. but without Chute. Foundation 13 feet	11954	6	8	Lt Fraser and McRead
–	–	–	1132	566	–	Standard plan	322	4	7	Mr Rear
–	–	–	28473	14236	–	Same as Suttsworth Foundations 15·75'	14926	5	5	Do
–	–	–	21273	9264	–	Same as at Mysmoodsm except that this Read has a Chute 146 feet long attached to it	11956	6	4	Do
–	–	–	4201	2100	–	Standard plan	1266	12	2	Lt Fraser and McRead
–	–	–	49148	24574	–	Same as at Sullawun	24174	13	2	Mr Rear
–	–	–	110368	55184	–	Do	65520	6	8¾	Lt Fraser and McRead
–	–	–	23156	11578	–	same as the above Valley	13204	3	7	Mr Read
–	–	–	1011	505	–	Standard plan	512	13	1	Do
–	–	–	26020	13010	–	Same as Suttsworth Foundations 11·25 feet	14231	3	7	Do
–	–	1656	–	–	–	Standard plan	513	1	4	Do
–	–	38508	–	–	–	Same as Suttsworth Foundations 10·75 feet	14434	7	5	Do
–	–	7056	–	–	–	Standard plan	1417	2	8	Do
–	–	35524	–	–	–	Same as Suttsworth Foundations 10·75 feet	14528	10	6	Do
–	–	1600	–	–	–	Standard plan	371	14	1	Do
–	–	35607	–	–	–	Same as Suttsworth Foundations 10 feet	12297	4	11	Do
–	–	1564	–	–	–	Standard plan	359	2	11	Do
–	–	35521	–	–	–	Same as Suttsworth Foundations 11 feet	12749	6	1	Do
–	–	1564	–	–	–	Standard plan	376	4	8	Do
–	–	72017	–	–	–	Same as Suttsworth but with Chute 160 feet long & similar to the Susquehanna ones – Foundations 10 feet	22571	3	7	Do
–	–	1586	–	–	–	Standard plan	501	1	10	Do

Hooghly 15	2½	2½	2	-	-	-	-	-	2	£	-	-	-	
Hooghly Bridge	103	-	79	1	3	50	7	2½	18	62777	+	470827		
Dasna Navigable Channel Head and Right Rajbuha Head	104	7	125	..	1	10	5	2	-	45382	+	340364		
Dasnah 1st Class Choki	105	4	105	..	-	-	-	-	-	12602	+	94515		
Dasnah Locks. Mills & Left Rajbuha Head	105	4	114	2	3	2	10	10	15	113566	+	851745		
Dasnah Falls	105	4	162	-	6	25	5	5	2	18	304886	+	228665	
Pepulheera Bridge and Ghats	106	6	84	2	3	45	6	2½	20	129472	+	971040		
Raoli Bridge	108	5	84	-	3	45	6	2½	18	84506	+	633795		
Bolunashur Branch Headworks														
Branch Regulating Bridge	110	2	96	-	3	27 15 14 28	6	1½	18	102817	282204	-	-	
Main Canal Do	110	2	193	1	8	20	6	1½	18					
Dubera 1st Class Choki	110	3	..	-	-	-	-	-	-	12518	1,00,000	-	-	
Nahaoli Bridge	113	6	..	.	3	45	6	2½	18	75093	191110	-	-	
Nahaoli 2nd Class Choki	113	5	186	2	-	-	-	-	-	2659	23800	-	-	
Jarcha 2nd Class Choki	116	4	163	1	-	-	-	-	-	2659	22800	-	-	
Jarcha Bridge	116	5	6	-	3	45	6	2½	18	72137	250111	-	-	
Seesoopoor 1st Class Choki	119	5	96	2	-	-	-	-	-	14222½	105460	-	-	
Seesoopoor Bridge	119	6	110	.	3	45	6	2½	18	74390	219122	-	-	
Sunowta 2nd Cl. Choki	122	4	153	1	-	-	-	-	-	2737	22800	-	-	
Sunowta Bridge	122	5	44	1	3	45	6	2½	18	79894	199620	-	-	
Pukkana 2nd Cl. Choki	125	4	153	1	-	-	-	-	-	2503	22800	-	-	
Pukkana Bridge	125	5	35	1	3	45	6	2½	18	78211	123900	-	-	

							16	&	99		
4	–	31388	–	–	–	Same as Attoora Foundations 11 feet	13604	11	4	Mr Foread	
–	–	22690	–	–	–	Same as Sullawar	9355	11	6	Do	
–	–	6301	–	–	–	Standard Plan	1524	10	3	Do	
–	–	56783	–	–	–	Same as Sullawar	14190	11	2	Do	
–	–	152443	–	–	–	Do	52639	12	8	Do	
–	–	64736	–	–	–	The water ways of Bridges are here reduced to 135' and the design is altered by Rusticated pilasters being dispensed with and the spandrils being in tact. Foundations 16'09	19046	12	6	Do	
–	–	42253	–	–	–	Same as Joseph Bellows Bridge Foundations 17'12.	15372	2	6	Do	
110132	191	28621	–	–	–	These works are situated at the point of departure of the Bolundhuben Branch and are connected together by Revetments. Flats and Platform Foundations from 5 to 15 feet deep –	18757	10	4	Mr Polk	
–	36	673	–	–	–	Standard Plan. 7' Foundations	1140	2	5	Do	
48668	141	18250	–	–	–	Same as Raoli. Cut with 100 feet flats on up Stream with Rubbles and Inlet Roads attached – Foundations 5½ to 6½' deep –	9871	14	11	Do	
–	7½	229	–	–	–	Standard Plan 6' Foundations	271	10	4	Do	
–	7½	158	–	–	–	Do Do.	233	3	5	Do	
34590	130	14553½	–	–	–	Like Nichaoli – Foundations varying from 5½ 67 feet	9070	4	9	Do	
–	37	6197	–	24	–	Standard plan – Inchkeith throughout. Foundations 9½'	1713	4	11	Do	
46128	135	16576	—	–	–	Like Nichaoli – Foundations from 5½ to 6¼ feet –	9827	10	11	Do	
–	4	137	–	–	—	Standard Plan Foundations 6½'	251	3	10	Do.	
25593	87	11329	–	–	–	Like Nichaoli. Foundations from 8 to 9' –	10975	5	10	Do	
–		contract	–	–	–	Standard Plan – Foundations 5'	225	11	..	Do	
72875	130	17043	–	–	–	Like Nichaoli – Foundations 5½ to 6 feet deep	11035	6	1	Do	

Dumkoura 1st Cl: Choki	128	4	120	-	-	-	-	-	-	9502	80000	-	-		
Dumkoura Bridge	128	4	150	..	3	45	6	2½	18	64018	141350	-	-		
Urrowli 2nd Class Choki	131	1	113	1	-	-	-	-	-	2893	27800	-	-		
Urrowli Bridge	131	2	14	-	3	45	6	2½	25	103226	199722	-	-		
Wullipoora 1st Bridge	133	6	108	1	3	45	6	2½	25	140066	210977	-	-		
Wullipoora 2nd Cl: Choki	133	6	208	1	-	-	-	-	-	2737	24800	-	-		
Mamun 2nd Cl: Choki	137	-	100	-	-	-	-	-	-	2560	21800	-	-		
Mamun 1st Bridge	137	-	213	1	3	45	6	2½	18	78375	145414	-	-		
Uchuhja 1st Bridge	139	5	189	1	3	45	6	2½	18	68253	139614	-	-		
Uchuhja 2nd Cl: Choki	139	6	86	1	-	-	-	-	-	2893	24450	-	-		
Moonda Khera 1st Cl: Choki	140	-	83	1	-	-	-	-	-	1388½	100000	-	-		
Moonda Khera Escape connected by Ghat with Moonda Khera Bridge	140	-	-	-	10	6	1½	1	-	178691	228184	-	-		
	140	-	116	2	3	45	6	2½	18						
Suhinda Bridge	144	5	6	..	3	45	6	2½	18	80147	113968	-	-		
Suhinda 2nd Cl: Choki	144	5	106	1	-	-	-	-	-	2560	21800	-	-		
Pubra Navigable Channel Head & Right Rajbuha Head (202 - 2 3/4 p. in 3D)	148	-	133	-	-	-	-	-	-	30653	36477	-	-		
Pubra 2nd Class Choki	148	4	212	2	-	-	-	-	-	2513	14312	-	-		
Pubra Falls	148	5	160	-	5	20	6	1½	18	174375	221141	-	-		
Pubra Locks, Mills & Left Rajbuha Head	148	5	160	-	-	-	-	-	-	69827	83094	-	-		
Koel Branch Headworks															
Branch Regulating Bridge	151	7	123	-	31	27/17 15/20	6	1½	18	87149	152445	-	-		
Main Canal Do	151	7	145	-	6	20	6	1½	18						
Koel Branch Head 1st Class Choki	151	7	213	-	-	-	-	-	-	1285½	64114	-	-		
Daoopoor 2nd Class Choki	155	3	114	-	-	-	-	-	-	2671	14312	-	-		

Taken. 617 250 Wullipoora. Do Do.

							8			9	10	
[illegible]	25	402½	-	-	1	Standard plan - 2½' Foundations	958	15	11	Mr Poolk		
50700	95	14974½	-	-	5	Similar to Nidhaoli - but having no Regulator in Inlet Head. & the Sluices placed on down Stream in Head Spurs - Foundations 5' & 6½'	8604	7	2	Do -		
-	7	230	-	-	1	Standard plan - 7½' Foundations	267	11	3	Do		
69755	104	21572	-	-	4	Differs from the Nidhaoli Bridge only in Sluices & approach to Sluices & in the details of finish - Foundations 5½' to 8'.	13967	6	-	Do		
103447	168	34353½	-	-	3	Like the Nidhaoli Bridge but has Sluices 350' long Foundations 8' to 8½' feet -	17191	9	9	Do		
-	6½	241	-	-	1	Standard plan - 6½' Foundations	254	4	..	Do		
-	2	58	-	-	1	Do 5½' Foundations	229	6	8	Do		
70300	77	19101	-	-	3	Like the Nidhaoli Bridge Foundations 6' to 6'.. 2" -	10383	3	3	Do		
56600	56½	15308	-	-	2	Same as Dumkhowa Bridge Foundations 7'.6" to 8'.6"	9017	2	7	Do		
-	4	146	-	-	1	Standard plan. 7½' foundations	255	11	2	Do		
-	30	2640	-	-	2	Do 6' on Pukka throughout -				Do		
128206	420½	53058	-	-	5	Escape and Bridge which is similar to Nidhaoli Bridge are connected together by a Sluice 380' long. Foundations 9'.7" to 10'.1" -	22976	2	4	Do		
67300	134	19268	-	-	2	Like Nidhaoli - Foundations 6'.6" to 6'.8" -	10182	7	10	Do		
-	5	150	-	-	1	Standard plan. 5½' Foundations	248	3	4	Do		
22978	22	8099	-	-	1	Same as at Mymoodpore	-	-	-	Do		
1200	7	273	-	-	1	Standard Plan - 5' Foundations	324	10	..	Do		
28802	117½	48318	-	-	2	Same as at Sullawah - but water way decreased to 100 feet -	31620	1	1	Do		
50065	61	16449	-	-	1	Same as at Sullawah				Do		
93100	236½	25385			2	Same as at Bolundshuhur Branch Road - Foundations 5 feet -	16752	14	9	Do		
6300	20	1752			1	Standard Plan - 7½' foundations	1482	1	1	Do		
1500	8	497			1	Do 6' foundations	371	13	5	Do		

Dadpoor Bridge	155	4	11	-	3	40	54	2½	18	71399	158594	-	-		
Birowli 2nd Class Choki	158	..	166	2	-	-	-	-	-	2513	14225	-	-		
Birowli Bridge	158	1	62	..	3	40	54	2½	18	70702	136201	-	-		
Dubtulla 2nd Class Choki	161	1	46	2	-	-	-	-	-	2513	13757	-	-		
Dubtulla Bridge	161	1	152	-	3	40	54	2½	18	71527	141280	-	-		
Simra Navigable Channel Rea & Right Rajbuha	162	6	25	-	-	-	-	-	-	30653	45979	-	-		
Simra 2nd Class Choki	163	2	82	-	-	-	-	-	-	2394½	14432	-	-		
Simra Falls	163	3	61	-	5	20	6	1½	22	186063	276304	-	-		
Simra Locks. Mills & Left Rajbuha Head	163	3	61	-	-	-	-	-	-	14790	112185	-	-		
Kasimpoor 1st Cl: Choki	166	3	100	..	-	-	-	-	-	14392½	22163	-	-		
Kasimpoor Escapr connected by Khals with Kasimpoor Bridge	166	3	31	2	10	6	1½	1	-	165707	267957	-	-		
	166	3	160	.	3	40	54	2½	18						
Burotha 2nd Cl: Choki	170	-	46	2	-	-	-	-	-	2829	11000	-	-		
Burotha Bridge	170	..	163	1	3	40	54	2½	22	76564	152749	-	-		
Machoora 2nd Cl: Choki	172	7	186	-	-	-	-	-	-	2829	13632	-	-		
Machoora Bridge	173	-	83	-	3	40	54	2½	18	69098	142868	-	-		
Chungeyri 2nd Cl. Choki	175	3	58	-	-	-	-	-	-	3145	14000	-	-		
Chungeyri Bridge	175	3	171	2	3	40	54	2½	18	59809	131500	-	-		
Sheka 2nd Class Choki	177	6	95	-	-	-	-	-	-	2987	16000	-	-		
Sheka Bridge	177	6	212	.	3	40	54	2½	22	78118	153500	-	-		
Nanoon Remainder															
Kawnpoor Branch Regulating Bridge	180	7	52	..	5	20	6	1½	25	132228	228400	-	-		
Etawa - Do -	180	6	146	-	5	20	6	1½	25						
Nanoon 1st Class Choki	180	7	102	-	-	-	-	-	-	13881½	76000	-	-		

4	-	-	-	Feet	-	16	8		9 11	2
62005	84	21833	-	-	-	Same as Nidhadie - but water way reduced to 120 feet - 6' Foundations	10125	3	7	Mr Volk.
1200	9	497	-	-	-	Standard Plan 5' foundations	334	8	11	Do
57043	74	21285	-	-	-	Same as Daoposr - 5:11" Foundations -	9316	3	10	Do
1200	9	382	-	-	-	Standard Plan 5' foundations	347	3	7	Do
42250	88½	23678	-	-	-	Same as Daoposr - 6:11' foundns	9867	13	2	Do
19311	26½	9140	-	-	-	Same as Pulau Z				Do
1200	5	255	-	-	-	Standard Plan 4½' foundations	33982	5	8	Do
122790	198	54417	-	-	-	Same as Pulau	360	6	10	Do
47117	66	22302	-	-	-	Do 2				Do
8200	-	3866	-	-	-	Standard Plan - Pulikko strongbarr - 9½' Foundations	1720	14	9	Do
94553	9½	48056	-	-	-	Same as at Moondakkam Foundations 7':11" -	20415	9	..	Do
1300	-	236	-	-	-	Standard Plan - 7' foundations	344	11	11	Do
57912	56	23953	-	-	-	Same as Daoposr - 7' foundns	10751	11	8	Do
1500	-	228	-	-	-	Standard Plan - 7' foundns	362	12	8	Do
85345	51	21907	-	-	-	Same as Uchuly a - except with Water way - 5 to 6 feet foundations	10424	11	1	Do
1500	-	455	-	-	-	Standard Plan 9' foundations	344	12	6	Do
58705	49	19436	-	-	-	Same as Machoor a - 6:3" foundations -	10120	6	1	Do
1360	-	185	-	-	-	Standard plan 8' foundations	348	14	8	Do
63800	82	23611	-	-	-	Same as Machoor a - 5 to 6 feet foundations	12048	1	3	Do
103325	105	36137	-	-	-	Same as Bolandeshwar 6' feet foundations	20864	14	11	Do
10200	-	2132	-	-	-	Standard plan - 9' foundns	1926	13	3	Do

Etawah Terminal Line -														
Chitrowli 2 Class Choki	2	5	12	2	-	-	-	-	-		4160	14400	-	-
Chitrowli Bridge	2	5	112	2	3	33	4½	2½	18		71001·63	97808	-	-
Bujrungpoor 2nd Class Choki	4	4	112	2	-	-	-	-	-		3329	15800	-	-
Bujrungpoor Bridge	4	4	213	1	3	33	4½	2½	18		71627·232	99200	-	-
Bijeegurh 2 Class Choki	7	4	85	-	-	-	-	-	-		3480	16200	-	-
Bijeegurh Bridge	7	4	212	2	3	33	4½	2½	18		69207·582	91488	-	-
Jao 1st Class Choki	10	4	163	1	-	-	-	-	-		16064	70000	-	-
Jao Bridge	10	5	17	1	3	30	4	2¼	18		68601	85119	-	-
Lodipoor 2nd Cl: Choki					-	-	-	-	-		2778	14600	-	-
Lodipoor Bridge	13	1	152	-	3	30	4	2¼	18		59687·49	92728	-	-
Kutai 2nd Class Choki	15	2	187	1	-	-	-	-	-		3643	2000	-	-
Kutai Bridge	15	3	110	1	3	30	4	2¼	18		64812·12	86791	-	-
Seetapoor 2nd Cl: Choki	17	7	158	1	-	-	-	-	-		3284	14600	-	-
Seetapoor Bridge	18	-	92	-	3	30	4	2¼	18		59687	83666	-	-
Pilkutra 1st Cl: Choki	20	5	161	1	-	-	-	-	-		14988	63350	-	-
Pilkutra Bridge	20	6	44	-	3	30	4	2¼	18		61110·5	89528	-	-
Noh 2nd Class Choki	23	2	21	2	-	-	-	-	-		3580	15500	-	-
Noh Bridge	23	2	219	-	3	30	4	2¼	18		68350·9	94287	-	-
Oreyee 2nd Cl: Choki	25	5	135	-	-	-	-	-	-		3350	15500	-	-
Oreyee Bridge	25	6	10	2	3	30	4	2¼	18		66758	102143	-	-
Gubrana Bridge	28	2	89	-	3	30	4	2¼	18		39693·8	37600	-	-

2442	2	350	–	–	–	Standard Plan - 13 Block Kunkers Foundations	468	11	6	Lt. Whiting
58775	104	13568	–	–	–	Design similar to foregoing Bridges but water way reduced to 99 feet - and Abuts only 60 feet long - Reinforced Wing Walls attached the former 10 ft wide and floor 2 ft under bed of Canal - Foundations 6' -	10046	14	1	Do
1443	2	300	–	–	100	Same as Chitrowli	388	12	8	Do
59235	264	15491	–	–	464	Same as Chitrowli	10837	13	9	Do
1554	2½	340	–	–	–	Do	399	4	3	Do
52900	196	14526	–	–	–	Do except in shape of cornice and having Piers plastered - & Face of Arches with Block Kunkers	10293	1	4	Do
8000	20	2576	–	–	170	Standard plan - except that roof over porches is built up level with centre room to form a flat case -	2531	7	7½	Do
56406	218	14163	–	–	–	Same as Chitrowli - but water way reduced to 90'	10889	8	1	Do
1045	–	438	–	–	–	Same as Chitrowli arches faced with Block Kunkers —	365	1	10½	Do
48113	234	13187	–	–	–	Do	8876	27		Do
3643	–	430	–	–	–	Do but built entirely of Block Kunkers - except Arches	672	8	..	Do
53286	227	11857	–	–	–	Same as Chitrowli - arches faced with Kunkers -	9698	7	10	Do
1552	–	330	–	–	120	Same as Chitrowli	432	12	4½	Do
48838	226	13252	–	–	810	Do Arches faced with Block Kunkers	9679	2	1	Do
72505	14	1900	–	–	–	Same as Sao -	1953	8	10	Do
49840	243	13082	–	–	943	Same as Chitrowli	9489	14	3	Do
1700	–	385	–	–	–	Do	442	..	8	Do
56568	120	12916	–	–	410	Do	9094	7	..	Do
1500	–	380	–	–	–	Do	415	2	2	Do
53980	145	14504	–	–	–	Do	8936	10	11	Do
30105	32	8127	–	–	490	Do but has no Ghats - Roads & Bunds &c —	5341	15	..	Do

Sonari 2 Class Choki	31	1	180	-	-	-	-	-	-	3805	1600	-	-		
Sonari Bridge	31	2	57	..	3	26	3½	2½	18	63391·1	82785	-	-		
Soraon 1 Class Choki	33	3	40	-	-	-	-	-	-	16285	72000	-	-		
Soraon Bridge	33	3	161	-	3	26	3½	2½	18	63907·4	98657½	-	-		
Kutana 2 Class Choki	35	6	46	2	-	-	-	-	-	3327·	16000·	-	-		
Kutana Bridge	35	6	134	-	3	26	3·5	2½	18	63907·4	102204½	-	-		
Jeypa 2 Class Choki	39	1	-	-	-	-	-	-	-	3290	16200·	-	-		
Jeypa Bridge	39	1	120	-	3	26	3½	2½	18	64501·5	70850·	-	-		
Peydhut 2 Cl: Choki	41	-	11	-	-	-	-	-		3290·5	13200	-	-		
Peydhut Bridge	41	-	90	2	3	26	4	2	18	65325·8	81300	-	-		
Kanakowa 2nd Class Choki	43	1	93	1	-	-	-	-	-	3290	13200	-	-		
Kanakowa Bridge	43	1	166	2	3	26	4	2	18	61352·5	68500	-	-		
Puteeka 1st Cl: Choky	46	3	93	1	-	-	-	-	-	16620	65000	-	-		
Puteeka Bridge	46	3	216	2	3	26	4	2	18	62074·9	88000	-	-		
Burragam 2nd Class Choki	49	3	126	2	-	-	-	-	-	3290·5	13200	-	-		
Burragam Bridge	49	4	11	2	3	26	4	2	18	59167·4	1,00,000	-	-		
Koosiarri 2nd Class Choki	52	3	36	2	-	-	-	-	-	3171·5	13200	-	-		
Koosiarri Bridge	52	3	136	2	3	26	4	2	18	58767·5	200000	-	-		
Futtehkhan's 2nd Class Choki	54	7	40	-	-	-	-	-	-	3171·5	13200	-	-		
Futtehkhan's Bridge	54	7	140	1	3	26	4	2	18	56952·5	138000	-	-		
Gihror 1st Cl: Choki	57	4	61	1	-	-	-	-	-	15238·	60000	-	-		

3000	..	430	–	–	–	Block kunkur work throughout except in arches	580	11	1	Capt Whiting
52894	111	13082	–	–	537	at this Bridge the water way is reduced to 78 feet. and the Regulating Heads are only 6 feet wide with Flooring 16 inches above bed	8521	1	7	Do
7777	4¼	2160	–	–	140	Same as at Jao	2224	6	7	Do
51326	135	11622	–	–	438	Arches faced with Kunkur	8353	..	4	Do
1443	3	270	–	–	106	Same as Chitrowli	409	8	6	Do
50680	126	12000	–	–	1080	Same as Sonari Bridge	8442	13	..	Do
1554	2½	280	–	–	112	Same as Chitrowli	413	4	10	Do
55940	93	12006	–	–	550	Same as Sonari Br:	8494	14	9	Do
1593	–	561	–	–	60	Same as Chitrowli.	453	12	11	Do
55164	72	15170	–	49	225	Same as Sonari. but Ghats are 100 feet long	9073	11	4	Do
1593	–	300	–	–	115	Same as Chitrowli	415	2	7½	Do
52789	63	16490	–	39	750	Same as Sonari	8570	10	9	Do
8600	9	3043	–	–	1447	Same as at Jao but pukka throughout	2574	14	..	Do
51067	38	18150	–	–	–	Same as Sonari. but Ghats are 75 feet long	8661	2	9	Do
1593	–	562	–	–	57	Same as Chitrowli	453	10	8	Do
46710	28	14290	–	–	–	Same as Sonari	8055	6	..	Do
1474	–	639	–	–	288	Same as Chitrowli but pukka throughout	472	2	11	Do
33180	14	14905	–	–	–	Same as Sonari. except that Canal Embankment retaining wall is dispensed with.	8869	12	6	Do
1474	–	236	–	–	200	Same as Chitrowli	410	13	5	Do
39697	60	14123	–	–	.	Same as Koosiari	8392	15	..	Do
7725	17	2398	–	156	868	Same as Jao –	2377	13	10	Do

Gihror Bridge with connected Escapt. and extra Bridge on Escape Channel	57	4	158	-	2	33	4	2	25	134699	180000	-	-		
Lawnpoor Terminal Line															
Keylunpoor 2nd Class Choki	2	5	165	..	-	-	-	-	-	3517	6927	28200	-	-	
Keylunpoor Bridge	2	6	34	2	3	33	4½	2½	20	81543	317112	69655	-	-	
Rudam 2nd Cl: Choki	6	2	65	2	-	-	-	-	-	3820	1800	40812	-	-	
Rudam Bridge	6	2	160	..	3	33	4½	2½	18	61391	388417	-	-	-	
Ginnowli Escape	9	2	4	-	3	6	1	1	-	14231	85200	-	-	-	
Ginnowli 2nd Cl: Choki	9	2	62	-	-	-	-	-	-	3460	7500	23500	-	-	
Ginnowli Bridge	9	2	113	1	3	33	4½	2½	18	61421	368480	-	-	-	
Baramai Bridge	11	2	186	2	3	33	4½	2½	20	47860	347585	-	-	-	
Sikundra Rao 1st Class Choki	12	1	133	1	-	-	-	-	-	13283	-	-	-		
Powdilnuggar Bridge	12	7	215	-	3	33	4½	2½	20	63057	192338	219394	-	-	
Dirrowli 2nd Cl: Choki	15	7	29	1	-	-	-	-	-	2723	26738	-	-	-	
Dirrowli Bridge	15	7	116	2	3	33	4½	2½	18	61832	136252	200004	-	-	
Dunsoi 2nd Cl: Choki	19	2	122	2	-	-	-	-	-	3862	34809	-	-	-	
Dunsoi Bridge	19	2	213	1	3	33	4½	2½	18	62602	210910	-	-	-	
Sultanpoor 1st Cl: Choki	22	5	66	2	-	-	-	-	-	14882	-	118510	-	-	
Sultanpoor Bridge	22	6	5	-	3	32	4½	2½	18	65779	-	161750	-	-	
Bundi 2nd Cl: Choki	26	6	50	..	-	-	-	-	-	3470	7479	13080	-	-	
Bundi Bridge	26	6	166	2	3	31	4½	2½	18	54808	175441	66030	-	-	
Guddunpoor 2nd Cl: Choki	29	2	189	1	-	-	-	-	-	2874	17048	-	-	-	
Guddunpoor Bridge	29	3	56	2	3	30	4	2	20	58088	310793	-	-	-	

112337	85	34248	-	-	-	The design of these works is similar to those at Moonda Klein	18009	4	3	Capt Whiting
-	-	73	-	53½	-	Standard plan	382	3	9	Lt Hodgson
29787	-	25668	-	-	4310	Has Ghats 60 feet long, Road retaining Revetments Inlet Heads - and Ruybuhas Heads 10 feet wide - also a drop in floor of 2 feet	11742	11	7	do
-	-	86	-	17½	-	Standard plan	394	12	0	do
-	22249	-	-	1620	7398	Same as at Keylumpore but without drop in floor	10192	14	10	do
2270	-	5800	-	-	1136	is not connected with Bridge	2213	5	9	do
-	-	122	-	58	52½	Standard Plan	404	12	..	do
9853	-	24073	-	501½	4957	Same as Rudain	10071	14	9	do
-	-	18117	-	1226	3157	Same as Rudain but has no Ruybuhas attached. 8 Ghats are on down stream -	8190	15	7	do
-	-	-	-	-	-	Standard plan	1250	12	1	do
11064	-	24449	-	2665	5282	Same as Rudain	10659	13	5	do
-	-	131	-	78½	-	Standard plan	310	4	8	do
23352	-	18631	-	2084	5339	Same as Rudain	9930	7	6½	do
-	-	136	-	48	-	Standard plan	455	3	6	do
38276	-	20278	-	3179	5726	Same as Rudain	9627	..	9	do
264	-	1762	-	61	37	Standard plan	2006	14	11	do
52291	-	26107	-	30	5932	Same as Rudain - except in reduction of waterway	10935	1	5	do
1200	-	199	-	-	16	Standard plan	402	2	2	do
32492	-	16826	-	236	5190	Same as Rudain	9390	13	..	do
-	-	144	-	-	96	Standard plan	393	14	8	do
17224	-	15779	-	1102	5534	Same as Rudain	9854	6	1	do

Goyalpoor 1st Cl: Choki	32	6	204	2	-	-	-	-	-	13926	66352	-	-	-	
Goyalpoor Bridge	32	7	73	1	3	29	4	2	18	54819	302325	-	-	-	
Dharoo 2nd Cl: Choki	35	4	120	-	-	-	-	-	-	2895	23860	-	-	-	
Dharoo Bridge	35	4	205	-	3	29	4	2	18	54142	233200	-	-	-	
Keylai 2nd Cl: Choki	38	5	89	1	-	-	-	-	-	2841	-	29407	-	-	
Keylai Bridge	38	5	170	-	3	29	4	2	20	58402	183746	79909	-	-	
Khoreet 2nd Class Choki	41	4	199	2	-	-	-	-	-	2777	19110	-	-	-	
Khoreet Bridge	41	5	76	2	3	28	4	2	18	54233	105192	-	-	-	
Mokumpoor 1st Class Choki	44	7	4	"	1	-	-	-	-	14270	96538	21513	-	-	
Mokumpoor Bridge	44	7	126	2	3	28	4	2	20	55414	232064	27942	-	-	
Nuggurea Escape	47	7	170	-	5	6	1	1	-						
Nuggurea 2nd Cl: Choki	48	-	35	-	-	-	-	-	-	3102	23424	-	-	-	
Nuggurea Bridge	48	-	133	1	3	28	4	2	18	52131	180815	-	-	-	
Puchowra 2d Cl: Choki	50	4	216	1	-	-	-	-	-	2339	21588	-	-	-	
Puchowra Bridge	50	5	83	1	3	27	4	2	20	53538	125435	-	-	-	
Kiraoli 2d Cl: Choki	54	"	123	-	-	-	-	-	-	3122	20532	-	-	-	
Kiraoli Bridge	54	"	205	1	3	27	4	2	18	52480	212863	-	-	-	
Dunnahar 1st Cl: Choki	57	4	124	1	-	-	-	-	-	14315	-	60557	-	-	
Dunnahar Bridge	57	4	213	1	3	26	4	2	25	64206	107303	15800	-	-	
Roostumpoor 2d Cl: Choki	60	7	110	-	-	-	-	-	-	2997	22576	-	-	-	
Roostumpoor Bridge	60	7	215	1	3	26	4	2	20	53800	99818	-	-	-	
Singhpoor 2d Cl: Choki	64	5	203	1	-	-	-	-	-	2881	11850	10693	-	-	
Singhpoor Bridge	64	6	63	1	3	26	4	2	20	53602	119841	-	-	-	
Putturhar 2d Cl Choki	67	4	145	1	-	-	-	-	-	2997	-	26530	-	-	
Putturhar Bridge	67	5	8	1	2	35	4½	2½	18	46810	23295	82270	-	-	
Bhaurunt 1st Cl: Choki	70	3	131	2	-	-	-	-	-	13985	52206	-	-	-	

6000	-	1434	-	-	326	Standard plan	1884	12	2	St Hodgson
20852	-	14140	..	628	5296	Same as Ouddain - with exception to Rajbuhas openings which are reduced to 6 feet -	8946	4	7	do
-	-	328	-	-	39	Standard plan	403	13	..	do
28516	-	13392	-	-	5354	Same as Gopalpore	8551	5	6	do
-	-	159	-	-	25	Standard plan	351	7	11	do
22477	-	15763	-	1526	7417	Same as Gopalpore	10007	9	3	do
-	-	72	-	108	64	Standard plan	349	.	1	do
41897	-	17820	-	-	8386	Same as Gopalpore	9402	15	7	do
-	-	555	-	203	99	Standard plan	1506	2	10	do
22797	-	17105	-	190	6529	Same as Gopalpore	9902	1	3½	do
							3340	5	11	do
-	-	172	-	-	8	Standard plan	347	1	3	
28534	-	16431	-	-	8138	Same as Gopalpore	8850	6	8	do
-	-	219	-	50	56	Standard plan	331	14	1	
38046	-	18538	-	-	11562	Same as Gopalpore	8865	3	9	- do
-	-	175	-	58	16	Standard plan	390	5	3	do
18236	-	18249	-	1077	5209	Same as Gopalpore - but no retaining Revetments to Bunds -	8099	4	6	do
6912	-	2382	-	-	356	Standard plan	2133	13	11	do
48815	-	20301	-	-	10606	Similar to Gopalpore but Bhats 80 feet long and no Rajbuhas Heads	12419	1	4	do
-	-	348	-	-	-	Standard plan	393	15	1	do
40478	-	20871	-	-	11787	Same as Gopalpore	9635	1	2	do
-	-	324	-	66	82	Standard plan	373	7	4	do
37171	-	19038	-	68	9992	Same as Gopalpore	9895	7	4	do
-	-	262	-	11½	50	Standard plan	401	8	10	do
44390	-	20772	-	-	12706	Same as Gopalpore but 2 Bays instead of 3	8025	.	6	do
4527	-	1678	-	-	472	Standard plan	1857	13	3	do

Bhaduut Bridge	70	3	210	.	2	35	4½	2½	20	56951	133520	15193	-	-
Sogaon 2nd Cl: Choki	74	1	138	-	-	-	-	-	-	2859	13867	-	-	-
Sogaon Bridge	74	2	2	1	2	33	4½	2½	18	49117	125413	5700	-	-
Kussuah 2nd Cl Choki	77	1	151	2	-	-	-	-	-	2984	15868	-	-	-
Kussuah Bridge	77	2	8	1	2	33	4½	2½	18	43400	129051	-	-	-
Ryhan 2nd Cl: Choki	80	4	136	2	-	-	-	-	-	3096	25358	-	-	-
Ryhan Bridge	80	4	213	2	2	33	4½	2½	18	46665	189163	34216	-	-
Dhundos 1st Cl: Choki	82	6	130	2	-	-	-	-	-	10671	48941	-	-	-
Dhundos Bridge	82	7	10	2	2	32	4½	2½	18	42646	178450	-	-	-
Sirra Escape	87	-	185	1	5	6	1	1	-	17437	38608	3625	-	-
Sirra 2nd Cl: Choki	87	1	31	2	-	-	-	-	-	2728	9467	10300	-	-
Sirra Bridge	87	1	87	1	2	32	4½	2½	20	48047	155497	9670	-	-
Futtehpoor 2nd Cl: Choki	90	2	187	-	-	-	-	-	-	2735	13402	-	-	-
Futtehpoor Bridge	90	3	57	-	2	32	4½	2½	18	48320	162126	-	-	-
Mirzapoor 2nd Cl: Choki	93	-	205	-	-	-	-	-	-	2687	15394	-	-	-
Mirzapoor Bridge	93	1	70	2	2	30	4	2	20	45001	264717	-	-	-
Dingurea 1st Cl: Choki	96	4	86	1	-	-	-	-	-		not begun			
Dingurea Bridge	96	3	178	2	2	30	4	2	18	49170	117313	-	-	-
Sureya 2nd Cl: Choki	98	4	32	-	-	-	-	-	-	2687	15510	-	-	-
Sureya Bridge	98	4	115	1	2	30	4	2	20	44457	132437	-	-	-
Kunsowa 2nd Cl: Choki	102	2	14	.	-	-	-	-	-	2580	22200	-	-	-
Kunsowa Bridge	102	2	78	2	2	30	4	2	18	47255	60842	-	-	-
Hussepur 2nd Cl: Choki	104	5	143	-	-	-	-	-	-	2580	19388	-	-	-
Hussepur Bridge	104	6	29	1	2	30	4	2	20	66949	16210	-	-	-
Bahosi 1st Cl: Choki	108	5	59	1	-	-	-	-	-	9260	76403	-	-	-
Bahosi Bridge	108	5	132	-	2	30	4	2	18	50893	19225	-	-	-
Gonaha 2nd Cl: Choki	111	-	4	2	-	-	-	-	-	2580	18975	-	-	-

34812	-	17049	-	1908	10260	Same as Puttahaw	9403	14	4	Lt Hodgson
1326	-	180	-	-	62	Standard plan	435	15	11	do
30829	-	15596	-	2024	10464	Same as Puttahaw but with reduced waterway -	8649	2	9	do
1372	-	244	-	10	106	Standard plan	407	13	4	do
28926	-	13100	-	1260	9040	Same as Sogaon	7095	4	5	do
-	-	315	-	4	44	Standard plan	396	.	4	do
16196	-	13652	-	1690	8296	Same as Sogaon	7617	1	1	do
4313	-	264	-	-	68	Standard plan not complete	-	-	-	do
20161	-	15699	-	-	6370	Same as Sogaon. but with reduced waterway	not complete			do
11970	-	5503	-	-	4291	Same as Nuggunna	2792	10	7	do
702	-	44	-	-	44	Standard plan	-	-	-	do
23397	-	13568	-	-	7915	Same as Dhundus	-	-	-	do
780	-	66	-	-	19	Standard plan	-	-	-	do
22317	-	12531	-	-	8058	Same as Dhundus	-	-	-	do
534	-	52	-	-	52	Standard plan	327	14	7	do
9699	-	11680	-	-	7736	Same as Dhundus but with reduced waterway -	-	-	-	do
						not begun				
12448	-	8230	-	-	5374	Same as Nirzapore	-	-	-	do
742	-	95	-	-	11	Standard Plan	324	1	10	do
25299	-	13968	-	-	6968	Same as Mirzapore	-	-	-	do
-	-	145	-	-	85	Standard plan	310	2	6	Lt Batchelor & Lt Hodgson
41162	-	11243	-	2615	6649	Same as Mirzapore	-	-	-	do
-	-	30	-	30	-	Standard plan	353	1	1	do
72297	-	11456½	-	9440	730	Same as Mirzapore	10286	15	1	do
3162	-	1147	-	930	-	Standard plan	1789	10	..	do
58712	-	10827	-	8130	1424	Same as Mirzapore	8651	2	"	do
-	-	195	-	60	-	Standard plan	308	9	"	do

Gonaha Bridge	111	-	74	-	2	30	4	2	18	63299	18737	-	-	
OOmurda 2d Cl: Choki	113	6	117	-	-	-	-	-	-	2580	19932	-	-	
OOmurda Bridge	113	7	16	2	2	30	4	2	18	45917	22364	-	-	
Sookhi 2d Cl: Choki	115	6	195	2	-	-	-	-		2580	18675	-	-	
Sookhi Bridge	115	7	26	2	2	25	4	2	15	44003	63510	-	-	
Khyrnugger 2d Cl: Choki	118	7	209	-	-	-	-	-	-	2580	18110	-	-	
Khyrnugger Bridge	119	-	66	2	2	25	4	2	15	52508	53301	-	-	
Sima 1st Cl: Choki	122	-	166	2	-	-	-	-	-	12365	97345	-	-	
Sima Bridge	122	-	200	-	2	25	4	2	15	45487	49202	-	-	
Banapoor Bridge	124	6	166	2	2	25	4	2	15	31846	61390	-	-	
Bidhun 2d Cl: Choki	127	1	13	-	-	-	-	-	-	2580	18920	-	-	
Bidhun Bridge	127	1	100	-	2	25	4	2	18	44982	65412	-	-	
Ootha 2d Cl: Choki	130	-	168	2	-	-	-	-	-	2580	18918	-	-	
Ootha Bridge	130	-	210	-	2	25	4	2	18	44783	160028	-	-	
Munowa 2d Cl: Choki	132	6	167	1	-	-	-	-	-	2580	18918	-	-	
Munowa Bridge	132	7	1	2	2	25	4	2	18	42824	299815	-	-	
Kukwan Escape	134	7	173	2	5	6	1	1	-	20419	120868	-	-	
Kukwan 1st Cl: Choki	135	-	57	-	-	-	-	-	-	94555	73337	-	-	
Kukwan Bridge	135	-	149	2	2	25	4	2	20	45102	307709	-	-	
Mudoopoor 2d Cl: Choki	138	-	115	1	-	-	-	-	-	2580	19018	-	-	
Mudoopoor Bridge	138	-	160	-	2	25	4	2	18	49609	112298	-	-	
Khoondun Bridge	140	3	41	2	2	25	4	2	15	32119	68113	-	-	
Tuktowli 2d Cl Choki	142	3	47	-	-	-	-	-	-	2580	19016	-	-	
Tuktowli Bridge	142	3	116	2	2	25	4	2	18	48740	121193	-	-	
Bhosan 2d Clan Choki	145	1	114	2	-	-	-	-	-	2580	17538	-	-	

66052	-	13836	-	11025	-	Same as Nusseynum	10561	9	4	Do Batchinis and Hobbadgum
-	-	45	-	-	5	Standard plan	380	13	3	do
58063	-	10300	-	8620	-	Same as Nusseynum	8853	15	7	do
-	-	171	-	105	-	Standard plan	360	9	2	do
37003	-	8143	-	7248	-	Same as Nusseynum but with water way raised	6287	1	5	do
-	-	100	-	60	-	Standard plan	351	13	3	do
53082	-	12143	-	10491	-	Same as Sookhi	8351	6	11	do
400	-	925	-	650	50	Standard plan	1748	2	11	do
38771	-	8034	-	10344	821	Same as Sookhi	6842	5	5	do
23710	-	9939	-	-	5255	do but with Rajbuhar Bends and Chats —	4999	14	1	do
-	-	95	-	185	-	Standard plan	373	13	1	do
37445	-	9017	-	6143	1825	Same as Sookhi	6530	1	4	do
-	-	96	-	190	-	Standard plan	355	14	..	do
32613	-	8810	-	6730	893	Same as Sookhi	6765	3	2	do
-	-	241	-	375	-	Standard plan	389	14	4	do
-	-	9829	-	6203	1479	Same as Sookhi	7311	1	3	do
3127	-	7626	-	-	5598	Same as Nugunnea	3214	2	10	do
-	-	1117	-	1169	-	Standard plan	1651	7	4	do
-	-	10721	-	5263	2682	Same as Sookhi	7334	2	7	do
-	-	166	-	221	-	Standard plan	393	8	..	do
37129	-	10071	-	7703	870	Same as Sookhi	7922	14	3	do
20740	-	10112	-	-	5918	Same as Banafoon	5238	9	6	do
-	-	118	-	99½	-	Standard plan	353	9	7	do
38224	-	8698	-	4347	827	Same as Sookhi	6744	11	7	do
4	-	146	-	62½	-	Standard plan	349	9	4	do

Bhosan Bridge	145	1	158	1	1	30	4	2	20	43835	205938	–	–		
Duggutpoor 1st Cl: Choki	147	–	111	2	–	–	–	–	–	16012	92929	–	–		
Duggutpoor Bridge	147	–	208	1	1	30	4	2	18	44266	31988	–	–		
Runjeitpoor 2d Cl: Choki	150	1	148	2	–	–	–	–	–	2580	18918	–	–		
Runjeitpoor Bridge	150	2	3	1	1	30	4	2	18	36093	190853	–	–		
Hookapoor 2d Cl: Choki	153	2	57	–	–	–	–	–	–	2580	20877	–	–		
Hookapoor Bridge	153	2	165	–	1	30	4	2	–	35645	246793	–	–		
Koosouli 2d Cl: Choki	156	–	136	2	–	–	–	–	–	2580	19436	–	–		
Koosouli Bridge	156	–	210	–	1	30	4	2	18	41652	275254	–	–		
Bana Bridge	158	3	73	1	1	30	4	2	18	41910	208619	–	–		
Bana 1st Cl: Choki	158	5	3	1	–	–	–	–	–	–	58010	–	–		
Muswanpoor Bridge	161	–	111	–	1	25	4	2	15	35617	233273	–	–		
Khujoori 2d Cl: Choki	–	–	–	–	–	–	–	–	–	2580	14341	–	–		
Khujoori Bridge	162	4	76	2	1	25	4	2	20	57439	375940	–	–		
Duborali Escape	164	4	126	1	–	–	–	–	–	48426	318913	–	–		
Duborali Regulator	164	5	206	1	1	20	2½	1 7/12	18	25185	169259	–	–		
Dukna poor on Grand Trunk Road Bridge	167	3	196	2	1	20	2 2/3	2	25	27785	76284	108541	–		

14052	-	10936	-	2510	3791	Design similar to last but with only 1 Waterway	6792	12	9	Lt Hutchinson & Lt Hodgson
132	-	472½	-	810	-	Standard plan	1685	9	7	do
38812	-	8978	-	3445	4855	Same as Rhosan	6737	6	5	do
-	-	320½	-	210	-	Standard plan	353	8	10	do
11384	-	8389	-	4356	2474	Same as Rhosan	not complete			do
-	-	64	-	41	-	Standard plan	371	4	11	do
891	-	10126	-	3078	2530	Same as Rhosan	not complete			do
-	-	53	-	52	-	Standard plan	344	2	9	do
-	-	10562	-	4606	2921	Same as Rhosan	not complete			do
-	-	5258	-	4768	456	Do.	5606	.	2	do
-	-	623	-	316	252½	Stand and plan	1421	12	7	do
1680	-	7702	-	5396	1398	Same as Rhosan	not complete			do
-	-	80	-	39	37½	Standard plan	349	12	4	do
3084	-	13826	-	5877	488	Same as Rhosan. but on a Skew of an angle of 53°. Revetments Chats. and Rustic work Beams arranged so as to give squareness to the front —	9341	10	6	do
-	-	17852	-	605	775	an Escape of 3 Openings on each side of the Canal with an underpassage of masonry for Counting drainage. Chokes on the Flanks —	not complete			Lt Hodgson
-	-	9705	-	306	205	Grooves are provided at this Bridge for Gates to shut off the Canal a Rustic work Beam of 10 feet Opening. for the Country between the Parapets and Ramps is also attached — Chats on both sides. and an Inlet on the left above Bridge form parts of this work —	do			do
3925	-	6486	-	291	2229	This is the first of the Campsie Series of works. it has Chats on upr Stream side with Inlets - but no Rustic work Beams - Pilasters and Rusticated piers	do			Lt Hutchinson & Lt Hodgson

Cawnpoor Works

No 1 Gunj Bridge	168	1	185	1	1	20	2⅔	1½	20	13879	63956	–	–	63
2 Do	168	2	166	–	1	20	2⅔	1½	20	12103	64386	–	–	66
3 Do	168	3	165	–	1	20	2⅔	1½	20	12328	60906	–	–	28
4 Do	168	4	151	–	1	20	2⅔	1½	20	11654	67602	–	–	13
5. Riddelés Do	168	6	128	2	1	20	2⅔	1½	20	9246	63000	–	–	11
6 Course Bridge	168	7	140	–	1	20	2⅔	1½	30	18052	118804	–	–	13
No 1 Lock	169	–	183	1	..	..	..	..	..	78311	272781	15950	–	28
Lower Road Bridge	169	3	57	2	1	20	2⅔	1½	30	12185	71500	–	–	16
No 2 Lock	169	4	126	1										
3 Do	169	4	167	2	–	–	–	–	–	47244	57313	21880	–	136
4 Do	169	5	151	2										
5 Do	169	5	192	2	–	–	–	–	–	Now commenced				
Terminal Works	169	6	13	2	–	–	–	–	–	–	152185	–	–	40
Canal and Esplanade Revetments Inlets &c. &c.	–	–	–	–	–	–	–	–	–	–	1241618	820106	–	766

Patkeu. 617 250 200 1000 10 Do. Do Do. Masonry.

th Each Work constructed on the Ganges Canal

6							7	8		9
als Expended										
Boulders	Block Kunkur	Lime			Sookee	Sand & Bujree	Description of the Work	Total Cost of the Work		Name of the Executive Engineer or Officer under whom built
		Stone	Kunkur	Earth						
Maunds	Cubic Feet	Cubic Feet	Cubic Feet	Cubic Feet	Cubic Feet	Cubic Feet		Cos Rs	as P	
		4	4	4	4	4	16	8		9
										(19)
–	–	6[illegible]21	–	2153	–	–	2284			Lt Hutchinson & Nougaw Lt Pilco.
–	–	6860	–	2323	–	–	2268			
–	–	2[illegible]59	–	2175	–	143	2038			
–	–	1[illegible]	–	1957	–	1957	–			
–	–	1[illegible]	–	2100	–	420	1600			
–	–	1[illegible]	–	4988	–	225	3247			
15950	–	26[illegible]	"	18336	–	4836	15737	196614	11	
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21880	–	136[illegible]		10403	–	3224	6327			
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APPENDIX

K

Reports on Dimāt and Bhosān Bridges

No. 194

From,

Lieutenant A. G. Goodwyn
Ex: Engineer Northern Division Ly. Canal

To,

Lieutenant Colonel P. T. Cautley
Director Ganges Canal Works,
Mussoorie 12th February 1850.

Sir,

I have the honor of forwarding herewith the report in duplicate of the committee which you in your letter No: 1798 of 4th Instant, ordered to assemble for the purpose of surveying the Dimat, Libereheri and Mungloor Bridges. This Report is accompanied by a Sketch shewing the general direction of the Sections of the Eastern Arch of the Dimat Bridge, illustrative of the remarks of the committee on this point, and also by a letter in original from Lieutenant E Sharpe Assistant Executive Officer of the 2d Division Ganges Canal.

2. The letter of the Executive Engineer 2d Division Ganges Canal received under cover of your cover, is herewith returned as directed.

I have the honor to be &c
(Sd) A. G. Goodwyn Lieutt.
Ex: Engineer Nr Div Ganal

4 Enclosures

Dimat 29th January 1850.

Sir,

In reply to your letter dated the 26th Instant. I have the honor to return the following replies to the queries contained in it.—

1st The Arching of the Eastern Arch was commenced on the 4th December 1849, and was kept on the 17th idem.

2nd I made it a point to visit the Bridge every

day. except when any other important business should detain me: but from this or any other cause a greater lapse than that of one day never intervened between any two consecutive visits-

3rd I obtained a supply of water for the Bridge Masonry from the village of Dimat, and two days supply was always received in a Tank built for the purpose, whence it was issued to the top of the Bridge by Bhishties in sufficient quantities, and whenever I saw the work going on the bricks were invariably soaked before being given to the masons, as it seemed in a manner habitual to them and I fully believe that they were always so wetted.

4th Sergeant O'Farrell Assistant Overseer never missed one day in his attendance at the Bridge, from the Commencement of the Arching to the 17th of December 1849. when he was seized with an attack of illness which precluded his attendance- That he was also punctual in the time of arrival and departure, I myself ascertained by varying the hours of my own visits, sometimes arriving there by sunrise, and sometimes at sunset-

I have the honor to be &c.
(Sd) Edmund Sharpe Lieutt. Artly
Assistt to Co: Engineer G. Canal

To,
Lieutt: Co. Fraser
Executive Engineer
Munglour Division
Ganges Canal
Munglour.

2nd Division Ganges Canal.

Report of a Committee which assembled in accordance with orders contained in letter No: 1798 dated 4th February 1850 from the Director of the Ganges Canal Works to the President. To Survey the Dimat Bridge over the Ganges Canal, and also those at Nimglow and Libeshni.-

Dimat 9th February 1850.

President

Lieutenant A. G. Goodwyn Ex: Engineer No. Div. Ganges Canal

Lieutenant R. Fraser, Executive Engineer 2nd Div. Ganges Canal } Members { Mr. Thomas Login Assistt Executive Officer No. Div. Ganges Canal

No.	Subject on which a Report is called for by the Director	Report and Remarks of Committee
1.	Quality of Material Bricks and Cement?	The cement is composed of one part Stone Lime to two parts Sookhee, and is of excellent quality. The dimensions of the Bricks used are 12·225" × 5·975" × 2·887 5 and they are of the best description, thoroughly burnt.-
2.	Quality of Workmanship in general, thickness of Seams of Arches especially?	The Method taken by the Committee in arriving at the Average thickness of Seam, has been to measure the original length of the arches over the extrados and under the intrados, taking the mean between these two measurements; then to count the number of Courses on edge in this length. This number multiplied by the Average thickness of bricks derived from a measurement of 10 taken out of one of these Arches, it has then been subtracted from the mean length of Arch, in inches, as obtained above, and the remainder being divided by the number of seams had given the following averages. In the East Arch .3857 inches In the Centre Arch .3397 inches In the Western Arch .385 7 inches

In the opinion of this Committee although the materials used are good, the Masonry, owing to bad workmanship, is entirely the contrary, except in the outer faces of the Arches. The Committee are of opinion that it is owing to this difference in the quality of the work that the outer portions have suffered crushing on the striking of the centres. In that Arch, the Eastern, the inside of which is exposed the Committee discovered a want of bedding of mortar for the bricks, which, they think, is, of itself sufficient to account for the failure of the work. In a letter from Lt. Co. Sharpe, the assistant in Executive charge of the work to the address of the Executive Engineer of the 2nd Division, that officer reports that the bricks were, when he visited the works, invariably soaked before they were given to the masons to lay and he expresses his belief that they were always so wetted. In this belief the Committee cannot concur. Should it be intended to be implied that the bricks were generally laid in a dripping state or that sufficient water was used, and they remark that that being Lt. Sharpes first Masonry work, and he being practically unaware of what essential importance, the free use of water in laying masonry in a climate as, is probably the cause of the discordance in their reports. The Committee also remark, that the bricks were not dressed before being laid, and that the boissons in the interior of the Eastern Arch, the only one in which they have been able by the removal of the Masonry to examine them, have not every where been constructed perpendicular to the curve of the extrados, as they were ordered to be, and should have been. Accompanying is a Sketch shewing this obliquity at various points along the interior Masonry of the Eastern Arch.

The

The Committee are aware that much of this obliquity is due to the sinking of the Arch, but think that some also is owing to imperfect workmanship. The bond prescribed by the Executive Engineer, as described to the Committee by that Officer, has not been carefully attended to, and the Committee observe an undue preponderance of headers. (ie. bricks set vertically, or nearly so.)

3 State of advance of Masonry in Wings and Spandrils at period when Centerings were struck?

When the Centres were struck the Wing Walls were level with the point where the curve of the extrados meets the imposts of the Arches, and the Spandril Walls had been carried up 2 feet 8 inches higher.-

4 State of induration of Masonry of Abutments, how long the Abutment Masonry had been allowed to stand before the Arches were built and how far earthwork was completed in their rear, at the time when the Centerings were struck?-

The Abutment masonry had stood about 7/5 days before the Arches were built. The induration of the cement is now very great, causing it to offer about the same resistance to an Iron point as a good pecla Brick. The earthwork in rear of Abutments was completed to the top of the Wing Walls prior to the final lowering of the centres of both Eastern and western Arches, but the Eastern Arch was lowered 6 inches when the Southern backing of the Abutment had only attained the level of the Springing line of the eliptical curve.-

5 Action of thrust upon Abutment if any to be described?

No appearance exists of any injurious action having accrued.

6 Whether to protect the works from contingencies arising from Neglect or Careless Superintendence on part of the Establishment on the work, either increased dimensions to the Abutment, or Modification to the direction

From Bridges having already been successfully built in the method designed for this one, the Committee consider the Merits of the plan established, and recommend no modification of it. The causes of failure appear entirely independent of the plan.-

of the thrust of the Arch, may be advantageously designed?-

7. The amount of supervision given by the assistant and overseer in charge of the particular work.

The Committee having in their answers to question 2, recorded their opinion of the causes of failure, beg to refer to the accompanying letter from Lieutenant C. Sharpe regarding the amount of supervision bestowed on the work by himself and by Sergeant W. O'Farrell, late assistant Overseer of this Division; and though not specifically ordered to report on this point, consider this supervision, as regards the number of visits of Lieutenant Sharpe, and the duration of the attendance of Sergeant O'Farrell, sufficient to warrant an expectation of good work.

The Committee further remark, with reference to the Centre Arch, which, having been lowered only one inch, at present stands uninjured, that they are satisfied, after a careful examination, that should the Centres be removed, failure here also will be the result.

They therefore recommend that it be immediately dismantled without lowering the Centres any further, or permitting further induration of the Cement, as the former operation would, in their opinion, crush many bricks, and further setting of the mortar would increase the difficulty of removing the Arch, without affording any fair prospect of advantage.

The Committee have inspected the Bungalow and Liberhei bridges also, -

which

which they find to be sound and well built.—

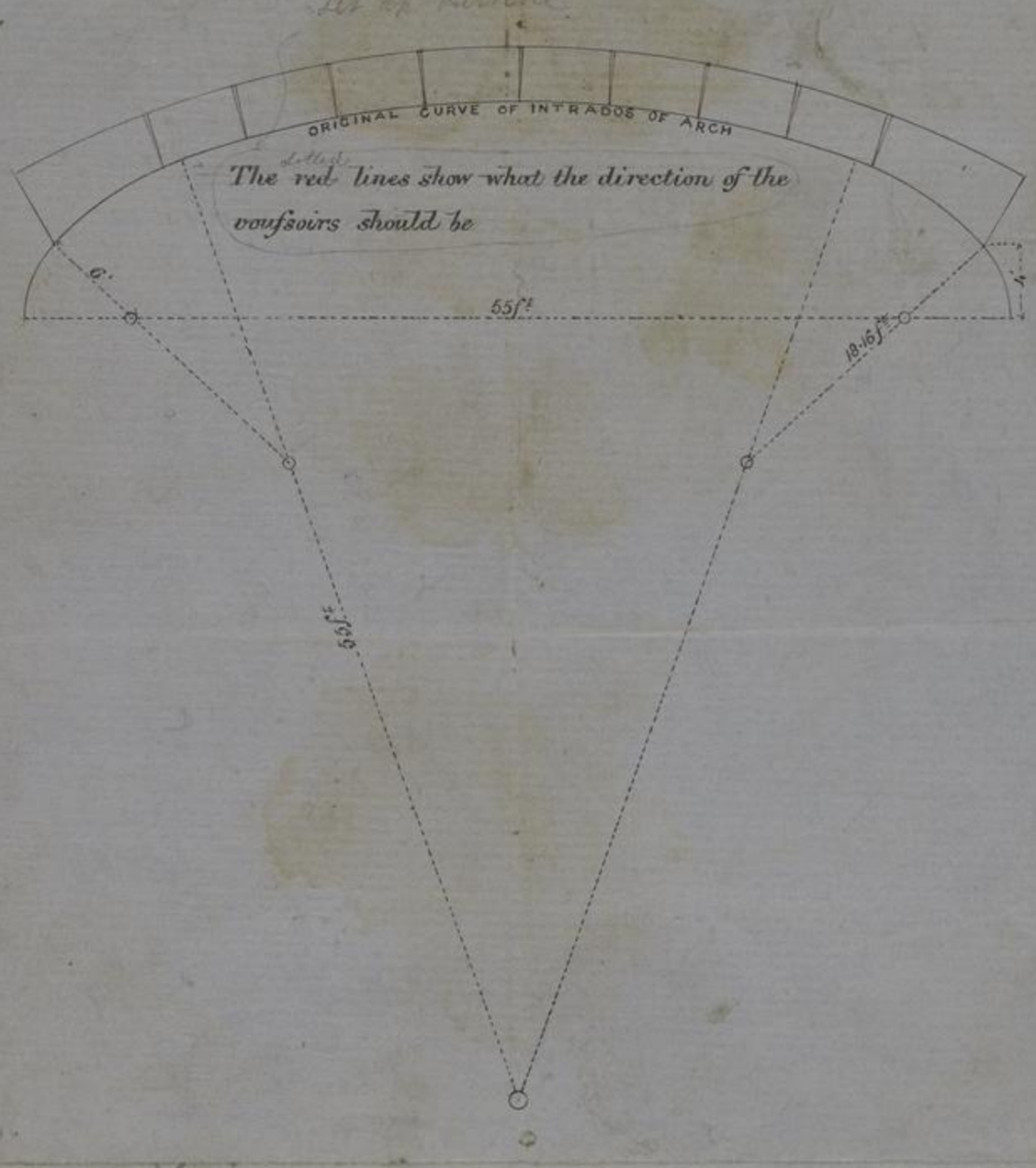
(Signed) A.S. Goodwyn Lieutt: Co: Engrs President
(Signed) C. Fraser Lieutt Co: Engineer Member
(Signed) E. Lozier. Asstt: Co: Officer Member

DIMAT BRIDGE

13.103.

Eastern Arch

Showing direction of voussoirs at distances of 5 Feet measured from the centre



No: 209 of 1851/52

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From,

Lieutenant E. W Hutchinson
Ex: Engineer 5th Div: Ganges canals

To,

Lieutenant Colonel P. T. Cautley
Director Ganges Canal &c.
Camp Kurkow 28th February 1852.

Sir,

I have the honor to report to you that a few days after the entire removal of the Centring (on Southern one) of the Bhosaw Arch it fell.

This Arch (and one of the Skewbacks) was built by contract by Mr. Hussey under the immediate Supervision of Mashrand, Sub Assistant Civil Engineer.

I attach a sketch of the state of progress in the adjoining side passages &c. and a dotted line shewing the position it assumed on falling.

The cause as it appeared to me of this accident, and as Lieutenant Hume (whom I sent for to meet me on the occasion of my visiting it after it fell) also thinks, was solely the very bad quality of the Masonry in the backing to the Arch (built by Mr. Hussey) and in the great quantity of Mortar used, and in the very inferior quality of this Mortar.

This Skewback was the first Masonry on the Bridge that was built by Mr. Hussey. the Abutment and the other Skewback were built previously by

Madhoram and are much better built.-

Madhoram states that he was absent on other works for the two or three days during which this was built, and was not aware it was so bad, although he was aware of the inferior quality of the Mortar, as he saw it used on his return in other parts of the Masonry, and at once insisted on its being properly prepared (it was not even ground or mixed in the Mill at first) and saw that better Lime was supplied to Mr Hussey.-

When I first visited the work, to see the quality of Mr Hussey's Masonry. I thought it so bad, in the portion of the side passage walls that were built, that I had them pulled down, and particularly pointed out to Madhoram, that he was to allow no such Masonry to pass. The Skewback was covered over on the top and I did not observe that it was so bad.-

The arch itself was very well built and the Mortar used in it is very good and the joints are fine.-

The Skewback has been, as shewn in the sketch, thrust off the Abutment almost, and on examining it, the centre of it appeared to have been stuffed with Mortar, and this Mortar had no hold of the bricks whatever. The Mortar was all in powder. The arch therefore had nothing whatever to resist its thrust save a few bricks.

Mr Hussey discontinued all Masonry work in the middle of January last, not finding sufficient profit in the rates I allowed him.-

217, 27

Having allowed him to carry on the arch and other Masonry work without having discovered the badness of the Skewback built by him, I conceive that I cannot in any way now call upon him to rebuild

any

any part of the fallen Masonry, or even find fault with him.-

The total loss by this accident is about 230 Rupees, and this will not cause the Estimate for this brige to be exceeded; especially as so much masonry had been struck off by the omission of the Ogee Walls.-

The Skew backs are now being rebuilt and after they have had four months to indurate the Arch will be again turned.-

I have &c.

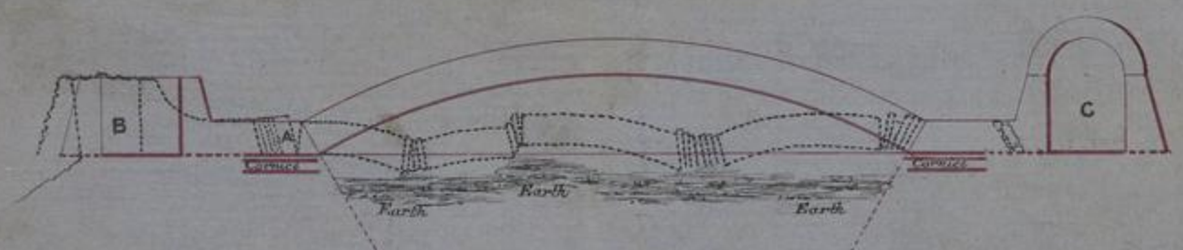
(Signed) A.W. Hutchinson Lieutt:

Ex: Engineer 6th Division Ganges Canal

BHOSAN BRIDGE ARCH

February 1852

B 102



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APPENDIX
L

System of keeping accounts introduced into the Roorkee workshops, by Mr Harry Marten

Memorandum on an Improved System for Conducting and keeping the Accounts of the Roorkee Workshops.-

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The communications which have taken place between Colonel Cautley and myself, having ended by his deciding that the management and account keeping of the Roorkee workshops, on their becoming independent of any particular work, shall be made to correspond as nearly as possible with what would be the system were the Factory to be worked by a Private Company; and having been desired to draw up a Memorandum on the plan which should be adopted for carrying out the object proposed, I beg leave to state that my General views regarding the Roorkee workshops are these:-

2. That they should be looked upon as, what they must ultimately become, a large Factory and General Furnishing Warehouse, whose objects are to manufacture and retail out, every description of Article required for Engineering purposes whether undertaken by the Government or by private individuals; and that in order to ensure these objects being gained, the Institution should be conducted on the principles which guide similar Concerns, the property of private Companies- the only difference being, that a private company would work its Factory for pecuniary profit- the Roorkee workshops would be worked merely to cover their expenses.-

3. The principal features involved in these views are:-

1st. That the Factory being conducted on the above principles- the Director of the Ganges Canal Works should represent the Interests of its Proprietors (the Government of India) and be

vested with powers, and act in every way, as if he were "Managing Director" (by which designation I shall hereafter refer to him) to a private Company.-

2nd That the Factory be made to pay all the expended incurred upon it - except for the Cost of the original Buildings and motive power, upon which (they being held as "Dead Stock" the property of the Government) it should pay the usual 5 per Cent Interest only.-

3dly That a Commercial System of Bookkeeping be introduced into the Office of the Factory.

4thly That as the business of the Factory will embrace Sales to private Individuals, and the supplying of Government Officials, the system of payment should be the same in both cases.-

4.- On the first point, there is hardly any necessity for my remarking upon the duties of the Managing Director:- he will of course watch with all possible vigilance the progress and growth of this promising Factory- Supply funds whenever necessary- Inspect the works and examine the Accounts - advise and control the Superintendent in every possible way without harassing him with useless details- make reports to Government on what had been done and way doing- Submit such periodical Balance Sheets and Progress Reports as would satisfy the Government as to the working of the Concern &c &c; but in order that his Interest in the Welfare of the Factory may not flag, he should be vested with some amount of discretionary power.-

5. In elucidation of the 2nd point- I would refer to the Books of account appended to this paper, and to explanations of the same which will presently

follow

follow under the title of "Instructions to Superintendent"
It will be seen that all expenses on

Repairs of Buildings
Permanent or Superintending Establishment
Wear and tear of Tools
Interest on Dead Stock.-

which is the extent of the contingent charges during the month fictitiously represented, are Debited to "Profit and Loss". To meet this Amount a per centage (which in the course of a few months may be very) approximately estimated (on all manufactured Goods going out of the Warehouse, is charged - and the amount so realized credited to "Profit and Loss" thus the Factory not only exhibits itself as no expense to the Government, but returns 5 per cent on the Value of its dead Stock - and, moreover, at once distributes its working expenses amongst those who have the best right to bear them :- Viz: the purchasers of Manufactured Articles, whether private individuals, or Government Departments.

6. On the 3rd point also, the best illustration of the advantages of a good system of Book-keeping, that I can give, is the Books themselves, and the explanations before adverted to; but to make this paper complete, I must, as briefly as possible, refer to them here - The particular system which I have illustrated in the appended forms is that known as "Double Entry" and is the one always adopted when large Interests are at stake, and when a merchant is desirous of shewing good Books: it is accuracy itself, for no error can creep into the Accounts without being detected when the Balance Sheet is being made out - With a careful Book-keeper, the Superintendent is relieved of all anxiety on the score of his Accounts; every transaction

being stamped in the Day book the moment it oc-
-curs, the rest follow in succession, and with this
surety, the Superintendent can devote the whole of
his time to his legitimate duties- As explained in
the instructions, the receipt or payment of money
is confined entirely to the office; nobody has the
handling of money but the Cashier; and the subordinates
of the Factory who incur expense either in labor, or
withdrawal of material from store, having each
made up his portion of the Daily Abstract, are
free of accounts- No delay, therefore, ought to oc-
-cur in the Books being kept up with regularity
and expenditure- and a days notice should be
sufficient to produce a Balance sheet com-
-prehensively shewing the state of the affairs
of the Factory on any given date- in addition
the Government is assured as much as may be
against fraud, for the Foremen, Overseers and Store-
-Keepers having nothing to do with payments
and the Cashier being able to disburse money
only on the indelible authority stamped on the
Daily Abstracts, no collusion could possibly
exist without being detected by a watchful
Manager.- The "Instructions" provide fully
for the Government and its Offices of account being
satisfactorily accounted to for what in Commercial
phrase, may be styled the risk embarked in the
Factory, while at the same time, from the compre-
-hensiveness of the system of Book-keeping- the Office
work not only in the Factory, but in all the offices
of Control, is reduced to a minimum.-

7. On the 4th point- My object is to secure the
Factory from the introduction of varying principles
in the conduct of its account, which would inevitably
create confusion, and suggest excuses for arrears. As
the sales to Private individuals must necessarily be
cash

cash transactions, I would make this the guiding principle - and demand similar cash payments from the Various Departments of Government that may purchase from the Factory - Although this is a mere question of principle, it has many advantages over the present course: for the Factory would be saved from submitting elaborately detailed bills twice over, (One to Government and one to Purchaser) and all the correspondence requisite for getting Bills passed and their amounts debited to the various Departments and the Department supplied with articles having paid cash for them is certain to bring the transaction on its books: not only, therefore, does that particular Department become at once answerable for the cost of articles necessary to its operations, but the Head Offices of account are able to rapidly adjust the true value of the Government property in each of its departments - at least as far as transactions with this factory are concerned - The money returns from these sources would often render the Factory independant of advances from Government and in this item also save some measure of Labor to its own and other Offices of the State - The monthly account Current which is to be submitted to the accountant shews how the Factory would account for money so received. -

8. In the accompanying forms of Books and Statements I have endeavoured to provide for the general wants of the Factory and in proceeding now to explain them, I shall enter upon other topics which will not only tend to make the proposed system understood but be suggestive of the orders that may be necessary on the separation of the Factory from the Gauges &c Canal works, as

Instructions to the Superintendent. -

9. The Managing Director has the General Control of all the Establishments attached to the Roorkee Factory - in him is vested authority for the appointment and dismissal of all permanent Establishment which comprises in addition to the Superintendent.

Deputy Superintendent
Practical Engineers or Foremen
Overseers
Mistrees
Warehousemen
Store Keepers
Book Keepers and Clerks in the Office -

and no appointment - nor dismissal - can be made in any of these Ranks without his Sanction. -

10. The Superintendent has the immediate and particular Control of all the Establishments, and of every department, attached to the Factory, and he has the arranging for, and disposing of Labor in such strength as the requirements of the work in progress - or about to be set in progress, may call for -

11. The Superintendents especial duties are Control - management - seeking, selecting and purchasing material best adapted to the purposes of the Factory - Devising methods and ways for turning to the best use all the Motive power, Machinery, Establishments &c. that he has at his disposal - Introducing improvements into existing designs - Adapting simple machinery, calculated to come within the comprehension of the Natives, - to the purposes of more costly and intricate inventions &c. &c.; and, in fact, while exercising a wholesome check upon every body and every thing placed under him, to endeavour by every means in his power to promote progress, and successfully work out the object of the Founders of the Institution -

Institution.-

12. The Superintendent might place his Office under the immediate charge of the Deputy Superintendent as one of his duties; and as all money is to be received into, and paid out of the Office he might Constitute him "Cashier" - he keeping the Cash Day Book (Form 1-).

13. In the working of the Factory it will be found convenient to keep the Manufactured Goods distinct from all other Stores - and of having a Warehouseman (European Assistant Overseer) in charge of them - and for executing all orders that may be received - In the Course of time, as the Manufactured articles increase in extent and interest a Show Room might be erected, and the things so arranged, that visitors might at once see the quality and description of work the Factory was able to turn out - The Warehouseman should keep his account of Stock in hand and Issues in a Tabular Form similar to that (Form 2) appended for the Storekeepers - So that the balance remaining in the Warehouse, after each days orders had been executed, might be seen at once, but the remaining account of the "Receipts and Issues" of each day should be kept in the form 2A and 2B.

14. The Superintendent being the Receiver of all Orders, would make any remarks upon them that he considered necessary; and send them to the Office for entry into the order Book (Form 3). This Order Book being sent to the Warehouseman, he would execute them to the extent his Stock admitted, and fill up the Columns left in the book with information expected from him - with Goods despatched he would always [send with att] a "List of Stores despatched" (Form 4) and should the Goods be going to a distance which [illegible] rendered..

rendered in advance of Cart hire necessary, he would note on this list - the total Amount of Cart hire to be paid - the advance made by the Factory, and the Balance to be paid by the receiver of the Goods. The presentation of this list, by the Chuprassy going in charge of the Stores, to the Cashier - would be sufficient warrant for his paying the Amount indicated - The Invoice of such dispatches would be made out from the Order Book and sent off by post, after its contents had been copied into the Invoice Book (Form 5) - Every manufactured Article sent out of the Warehouse is to bear a percentage to Cover the Cost of the expenses of the Factory - and this is added on in the Office, the Warehousemans Rates being those for the Cost of Material and Labor Only. -

15. The Office attached to the Factory is to be formed and Conducted on Commercial principles; & it is to be Comprehended every transaction Connected with the working of the Concern - Nothing should go out of, or come into the Factory without passing through it; all money must be received into, and paid from, it; and with exception to Muster Rolls, (Form 8) and Stock registers, no accounts whatever are to be kept away from it - The Daily Abstract Book will lie open in the Office, and such Subordinates as have to account for Labor employed under them, - Stores issued or received &c. will attend at the time that may be fixed upon for the purpose of entering into it the results of their days operations. - I deem it proper to leave to the Superintendent, whose duty it

especially

especially is, the fixing of each subordinates share in the filling up of this Daily Abstract- but my idea is, that a most excellent check might be established over this, the most important part of the Factory, by the Foremen and others having squads of workmen under them, being made to keep a memo: of the people employed- the materials received from the Yard in each of their sections: and when the general Musters was about to enter the details under each head of work, that they should compare their memoranda with the return of the Musterer- the same with the Store keepers; and attest the correctness of the entries by affixing each of their names to that portion which applied to their several sections.- This Daily Abstract would form one of the most important of the auxiliary books required- the form already in use in the shops (Form No: 7) is probably as good a one as can be devised- and the only addition wanted is a general Abstract to be made up by the Book Keeper, in which he should extract the rate for each article manufactured and transferred to the Warehousemans books- generally, this would be made up at the end of every month for posting to the principal books, but if the article completed was to be sent away immediately, the Abstract could at once be made out. The other auxiliary books are the Cash Day Book, and the Stock Books for which forms are given, and which require no explanation- their purposes being plainly stamped on their pages.

16. The principal books are the Day Book, Journal and Ledger; these are to be kept on the

system known as "Double Entry" the grand objects being, to secure to the Factory a faithful record of its transactions with the least amount of labor, and to show that the Factory pays the whole of its expenses, and returns to the Government 5 per cent Interest on its outlay in buildings and Motive power. In drawing up the forms of these books, I have supposed that the Superintendent has just received independent charge of the Factory; that he has taken over from Lieutt Goodwyn the whole of the Dead Stock, Machinery, Tools, Raw Material and Manufactured Goods that exist on the date of the Transfer. - and that he, subsequently, receives an advance of money from the Managing Director. By the first account in the Ledger, "The Government of India" I prove that it gets the Credit for these as well as for the Interest on its Dead Stock, and by the last account "The Balance Sheet" that the Credit so given is the actual Capital of the Factory, and that the books are correct.

17. The Day Book and Journal are kept in one book; the former occupying the left page, the latter the right one; and much time and trouble are saved by this arrangement, besides the surety of accuracy. - for if the entries in the Journal (which is the Index to the Ledger) are correct, the Totals of both its columns must agree and also correspond with the total of the Day Book column. - In the Day Book we commence with an entry representing the value of the Stock which we have to work upon - then follows the incomings and outgoings as they occur

occur. and on the last day of the month me bring forward in abstract the data afforded by the Daily Abstract in the expense that has been incurred in manufacturing and the months transactions are closed by the entries of all the contingent expenses of the Month.

18. The Journal is deduced from the Day Book and shows how the transactions are to be posted to the Ledger. Each Day Book entry calls for One Dr. and One Cr. in transferring it to the Journal. for the principle is that the Dr. must be equal to the Cr. and therefore the first item in the Day Book is transferred to the Journal as "Stock Dr. "to Factory Buildings &c." and "Cr. to the Government "of India" whose property it is. the next entry in the Day Book is a Draft which it is not convenient to Cash at Once it is consequently "Dr. to Bills "Receivable" and "Cr. to the Government of India" and when the Cashing of the Draft did take place it is "Dr. to Cash" and "Cr. to Bills receivable." the succeeding item "Sales of Manufactured Goods" is Dr. to Sleett "Goodwyn" the purchaser, and "Cr." partly to "Manu-"factured Goods" and partly to "Profit and Loss" the latter Amount being the sum charged for Factory percentage beyond the actual cost of the article. and which is set off to the Contingent charges of Superintending Establishment, percentage for wear and tear of Tools, and Interest on Dead Stock which are all "Dr. to Profit and Loss": the red figures are the folios of the Ledger to which the items are posted.—

19. The Ledger is the Chief of all the Books: a reference to it shews the exact State of each account—

and

and also of the affairs of the Concern for which it is Kept - a Balance sheet drawn up from it, at any time that may be required determining at once whether the Factory is going on well or otherwise. In the Book that I have prepared, the entries in the Journal before described, and all posted to their separate accounts, and by following them out it will be easy to understand how the Balance sheet tests the correctness of all the accounts that have gone before it. - I have only further to remark on this Book that I have judged it proper that the Profit and Loss account of the Roorkee Factory should admit on its Dr. side only those Contingent charges of its Establishment, Repairs of Buildings, &c., which the purchasers of Manufactured Goods have a right to pay, and on its credit side the sums realized by the percentage charged upon such goods; and that the value of the labor performed by Steam Engines after deducting the expense of working them, should instead of going to the Cr. of Profit and Loss form a fund either to decrease the amount value of Dead Stock - or to meet any unforeseen accident that may occur. - this idea having been carried out in these accounts, we find that after accounting to Government for all that is its due, there is a sum of Rupees 2590/-/- still to be worked off by the charge of Factory percentage on Manufactured Goods: the value of the stock of Manufactured Goods is 16,750 Rupees: - the 10 per cent which has been assumed for the months illustrated, upon this sum is not enough therefore to cover the Balance at

Debit

debit of Profit and Loss and during the subsequent month the Factory percentage charge must be raised to 15 per cent. accordingly as each months Balance of Profit and Loss is exhibited with reference to the value of the Stock of Manufactured Goods, so must the Factory percentage be raised or decreased. As the charge for Establishment, Repairs, Interest &c. is nearly a constant quantity, the percentage fluctuates according to the work done, and the Superintendent will therefore see that the more work he executes the lower will be the rate for Factory percentage, and consequently, the greater the credit due to his management. On the Steam Engine working account we see that there is a fund of Rupees 2,400 to meet any accidents or for appropriation as may be decided upon.

20. The Balances should be struck every month. the value of Stock in hand being taken from the accounts. At the close of each year, it would be a safeguard that the Balances of Stock should be corrected by an Inventory of every thing being taken.

21. The Book-keeper attached to the Factory will understand that he is responsible for the correctness of the Books and for their being brought up with regularity. If, at the Managing Directors Inspections this is found not to be the case, the Book Keeper alone will bear the censure.

22. Every manufactured article sent out of the Factory is to be paid for by the purchaser whether private individual, or Government official, and the amount so realized carried to the Cr. of the Factory by cash being made Dr. when other money is required for the purposes of the Factory application is to be made to the Managing Director.

23. The Superintendent will submit to the Managing Director as soon as each months accounts are closed. :—

1. Copy of the Ledger account with the Government of India.—
2. Copy of the Ledger Balance Sheet
3. Account Current (Form 6)
4. Copy of the Ledger Cash account
5. Copy of the Abstract of the Daily Abstract
6. Progress Reports
7. Acquittance Rolls for Salaries.

Nos: 1. 2. 3 and 6 will be forwarded by the Managing Director to the Military Board for their and the Governments information: No: 3 will also be sent to the accountant accompanied by the acquittance Roll— Nos: 4 and 5 will be retained in the Managing Director's Office, and will be his Checks upon the Factory.—

24. The papers above indicated as having to be submitted to the Board will render every information to the Government that could possibly be desired.— No: 3— from being in detail as regards the debits which are due to other Departments for the purchase of manufactured Goods, will place in the hands of the Board and accountant, the means of checking the charges brought forward in those Departments.

25. Changes in old established customs— no matter how beneficial they may profess to be are generally looked upon with suspicion: and, at first sight, it may be thought that in the proposals I have made there is an attempt to separate this particular Institution from the connection and control which the Government

now

now exercises over its several departments: I would however, disclaim any such intention, and urge that the only object I have, and I trust that the preceding pages have proved it, is to introduce into this Embryo Factory and General Furnishing House, some sounder systems of account keeping, by which it shall have every encouragement to proceed on and arrive at that state of usefulness which is contemplated by its Founders; and at the same time protect the Interests of the Government immeasureably better than the present imperfect system admits of.—

2nd June 1832.

(Sd) Harry Marten
Assistant

(Form 1)(-1) A/c. L 22½

a

Form of Cash Day Book

ate		Description	Folio of Journal	Expenditure	Receipts
2					
ay	15	Received from the Collector of Saharunpoor, Cash in lieu of Director's Draft No. 1 of 1832/33	1	" " "	10,000 " "
	20	Paid to the Monkland Iron and Steel Company for Iron	1	5000 " "	
	25	Received from Nychul for Goods	1	" " "	110 " "
	31	Paid Labor for May 1832	1	3590 " "	
		Paid Permanent Establishment for May 1832	1	1000 " "	
		Total		9590 " "	10,110 " "
	31	Cash Balance in hand		520 " "	
		Total Comps. Rupees		10,110	10,110 " "
	1	Cash in hand		" "	520 " "
4		27½	4	6	6

Lady

(Form 2) 4

d

Store Keepers account of Receipts and

Date		From whom received or to whom issued	Bar Rolled Iron 1½ Inch	Bar Rolled Iron 1¼ Inch	Bar Rolled Iron 3 Inches	Bolt Iron ⅞ Inch	Bolt Iron 1 Inch	Angle Iron 1¼ × ⅝	Angle Iron 1½ × ⅜	Rolled Iron 2 Inches
1852			Mds	Mds	Mds	Mds	Mds	Mds	Mds	Mds
May	1st	From Lt. Goodwyn	100	100	100	200	500	500	400	
	10	To Mr. ——— Foreman	50	"	50	"	100	-	-	
		10th May Balance	50	100	50	200	400	500	400	
	20	From Monkland Company	500	-	-	-	-	-	-	500
		20th May Balance	550	100	50	200	400	500	400	500
	31	To Mr. ——— Foreman	50	50	30	-	-	-	50	100
	"	To Mr. ——— Foreman	50	25	10	100	300	-	-	-
			100	75	40	100	300	-	50	100
4		31st May Balance	450	25	10	100	100	500	350	400
			3	-	-	-	-	-	-	-

18½

1 row

/ Form 2 /B

(c

Form of Order Book.

Descriptions of articles by whom required	Columns to be filled up by Warehousemen				
	Rate as stamping	Price of Stock	Incidental	Total amount as above	Total amount

Form 2 A

The Column for incidental expenses is intended to provide for the Registration of expenses that may sometimes be incurred when Goods are to be despatched to a distance- All advances to Cart= =men being made would appear here and be duly included in the Bill submitted to the purchaser- The attached Form for the Warehousemans "List of Stores despatched" will make this plain.

(Form 2a) Book of Receipts

Date	Description	No.	Quantity Mds. Srs. Cts.	Rate	Amount Rs. As. P.	Whence received	Remarks
1853 November 5	Tallow	.	20 " "	8/-	160 " "	Butcher	
	Bel Baskets	1000	" " "	1/p 19	32 10 1	Khanna Contractor	
	Malla do	600	" " "	57/p 1/	8 12 4		
	Iron Flatbar 4"x1"	"	50 " "			Delhie Magazine	
	Old Copper Cuttings	"	" 10 8			Shops	
	Old Steel files	"	" 14 4			do	
	Bolts 1st Class	300	13 8 10			do	
	Brass borings and filings	"	" 4 14			do	
	Railway Truck Wheels	40	" " "			Ex: Engineer	
	Wrought Iron 1st Class	"	2 4 "				
	do do 2nd "	"	4 9 7				
	do do 3rd "	"	15 4 9			Forged	
	Nails 2d Class	"	" 22 "				
	Lump Iron	"	" 32 "				
4		3	5	2	5		

/ Form 2 /

(2

Form of Order Book.

(Form 2 L) - Book of Issues (C

Date	No: of Work	Description	No:	Quantity	Remarks	
Nov 8	28	Pharoah Blades	20	1 2 3		
	28	— do — Sockets	20	" 18 "	Making up	
	28	2 Cl Clean Nuts	"	" 1 4		
	32	Leather Buckets	20	" " "	Co: Engineer	
	32	Country turnie	"	" 10 "	— Do —	
	Sots	2 Cl Clean	"	" 2 "	Mr Logie	
	"	Putty	"	" 4 "	Dr Burn	
	2	Old Copper	"	" 4 "	Brass furnace	
	2	Zinc	"	" 1 "		
	1	Old Iron pieces	"	21 6		
	1	Iron flat bar	"	4 17 3		
	1	" Square	"	" 24 8		
	1	" Rod	"	5 16 4	Forges	
	1	" Kheree	"	" 29 "		
	1	Shear Steel	"	" 1 8		
	1	Cast Steel	"	" 2 "		

4 3 24/2 5 5 @ 10

The Column for incidental expenses is intended to provide for the Registration of expenses that may sometimes be incurred when Goods are to be despatched to a distance- All advances to Carmen being made would appear here and be duly included in the Bill submitted to the purchaser- The attached Form for Warehousemans "List of Stores despatched" will make this plain.

Form 2 B

/ Form 3 /

(2

Form of Order Book.

Description of Articles by whom Requir'd. and date of Order	Columns to be filled up by Warehousemen: Rate as standing on Warehouse main Books	Date of Despatch	Incidental Expenses	Date to which order was entirely complied with
10th May 1852.				
Lieut A. G. Goodwyn Ex. Engr.				
Nos 1 to 5 Gauges to mail as per letter No: 5 of this date:—				
40 Side Tilt Wagons Complete Each	100 " "	May 10		
10 Brick Making Machines				
10 Pile Engines.				
25th May 1852				
Nyehul - Carpenter - for ready Money				
1 Carpenters Chest of Tools Each	100 " "	May 25		25th May 1852.
31st May 1852				
Workshops:				
1 Carpenters Chest of Tools ____ Each	100 " "	May 31		31st May 1852
1 Smiths ____ Do ____ "	50 " "	"		

The Column for incidental expenses is intended to provide for the Registration of expenses that may sometimes be incurred when Goods are to be despatched to a distance— All advances to Cart= =men being made would appear here and be duly included in the Bill submitted to the purchaser— The attached Form for the Warehousemans "List of Stores despatched" will make this plain.

225-2Z

/ Form 41 /

List of Stores dispatched to Colonel Napier, Civil Engineer, Punjaub, in part of his Invr. dated 1st July 1852

Roorkee Workshops 5th July 1852.

Bholee Bux, Chuprassy in Charge:-

Dhaums for Block-sinking	50
Windlasses for Do	50
Dhoonahs without handles	100
Brick making Machine	1

Conveyance:- 2 Town bullock Carts engaged to deliver the above articles at Lahore for Rs 30 " 0 . 0

Advanced by Roorkee Workshops Rs 5 " 0 . 0

Balance due - to be paid by Coll: Napier 25 " 0 . 0

A.B.

Warehousemen.

Form 517-1

Form of Invoice Book

9

te		Rate	Amount	Total
10	Lieutenant Goodwyn. Executive Engineer Northern Division Ganges Canals			
	40 Side Tilt Ballast Wagons complete with Spa Spa ——— @	100 " "	4,000 " "	
	Add Factory percentage @ 10 p Cent ———		400 " "	
	Grand total Company's Rupees ———			4,400 " "
15	Mychul, Carpenter, for Cash —			
	1 Chest of Carpenters Tools ——— @ ———	100 " "	100 " "	
	Add Factory percentage @ 10 p Cent ———		10 " "	
	Grand total Company's Rupees ———			110 " "
31	Factory.			
	1 Chest of Carpenters Tools ——— @ @	100 " "	100 " "	
	1 —— do —— Smiths —— do ——— @ @	50 " "	50 " "	150 " "

Form 6.

Form 6

Dr. The Superintendent of the Roorkee For the

1852					
May 1	To Received from Lieutt. Goodwyn Ex: Engr. Sr. & Dr. Canal				
	Dead Stock: Factory Buildings	50,000.0.0			
	Steam Engines	30,000.0.0	80,000	"	"
	Current Stock: Machinery and Tools	20,000.0.0			
	Iron	10,000.0.0			
	Timber	10,000.0.0			
	Manufactured Goods	10,000.0.0	50,000	"	" 130,0
15	To Cash received in lieu of Managing Directors Draft No 1 of 1852/53				10,0
30	To Interest @ 5 per Cent on Dead Stock				5
	Total Company's Rupees				140,0

Dr. Roo

1852					
May 31	To Balance due to Government of India				140,0
	To Cash Account				
	Received from Mychul for Sales		110	"	"
	To Increased Value of Stock by purchase and Manufacture during the Month.				
	Machinery and Tools	150.0.0			
	Manufactured Goods	11,000.0.0			
	Raw Material	5,000.0.0	16,150	"	"
	To Profit and Loss				
	Repairs of Buildings	1,000.0.0			
	Permanent Establishment	1,000.0.0			
	Percentage on tools	500.0.0			
	Interest on Dead Stock	500.0.0	3,000	"	"
	To Suspense Account				
	Balance due from Lieutt Goodwyn		3,400	"	" 22
	Total Company's Rupees				163

May 1852 — Jour. 5

Account Current with the Honble Company — 6d.

	26		Rupees 4	Rupees 4½
31	By Balance the Property of Government Carried to Debit of the Roorkee Factory			1,40,500 " "
	Total Company's Rupees			1,40,500 " "

Factory — 6d.

31	By Department Public Works			
	Sales to Lieut. Goodwyn Ex. Engr. N.D. Ganges Canals			
	40 Side Till Wagons @ 100/- /- @		4,000 " "	
	Factory Percentage		400 " "	
	Deduct — Total Comps. Rupees		4,400 " "	
	Amount by Lt. Goodwyn's Bill for Ordinary Repairs to Shops		1,000 " "	3,400 " "
	By Decrease of Stock by Issues to Works and Sales			
	Manufactured Goods		4,250 " "	
	Raw Material		5,010 " "	9,260 " "
	By Cash Account			
	Paid Moukland Company for Iron		5,000 " "	
	" Labor during the Month		3,590 " "	
	" Permanent Establishment		1,000 " "	9590 " "
	By Profit and Loss			
	Factory Percentage On Sales			410 " "
	By Balances			
	Dead Stock		80,000 " "	
	Machinery and Tools		19,650 " "	
	Raw Material		19,990 " "	
	Manufactured Goods		16,750 " "	
	Unrealized Balances		3,400 " "	
	Cash in hand		520 " "	
	Balance against Profit and Loss account remaining to be worked off by Factory Percentage		2,590 " "	
	Deduct — Total		1,42,900	
	Balance in favor of Steam Engine account		2,400	1,40,500 " "
	Total Company's Rupees			1,63,160 " "

Faustus

Hom 1

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Form 7 — 3

Daily Account of Work done in the Ro

No 1. Wrought Iron Work

Total No of Laborers Nationality	Rate	Amount	Total
14,504	½ ⅔	5 / 453 5 6	4 / 453 5 6
Total Labor		453 5 6	
22. 55. 12	6/1/.	137 5 10	
66. 4. 4	6/1/.	390 10 2	
59. 32. 4	6/1/.	235 13 5	
1. 36. 0	8/1/.	6 3 2	
10. 18. 0	4/4/.	44 6 4	
2. 15. 0	7/1/.	16 10 .	
0. 17. 6	15/10/2	1 4 8	
0. 26. 0	5/8/.	3 9 2	
1/6	. /3/.	3 3 . .	
610. 0. 0	. /6/.	603 12 .	
		1544 11 .	
	Total	1998. 6	

| Description | | Smiths | | |

Shops during the month of June 1853.

| Date | Description | | |

Day Book
and
Journal

Flag

Day Book

Date		Description				Amount
1852 May 4	1	Stock as received from Lieut. Goodwyn 39 4 —				5
		Value of Factory Buildings Stock Book page 1		Rupees 50,000	" "	Rupees
		Do — Steam machinery — do — 2		30,000	" "	
		Do — Machinery and Tools — do — 3		20,000	" "	
		Do — Iron in store — do — 4		10,000	" "	
		Do — Timber in store — do — 5		10,000	" "	
		Do — Manufactured Warehouse Goods — do — 6		10,000	" "	1,30,000
	5	Received from Director of the Works Draft on Saharunpoor Treasury at Sight, No: 1 of 1852/53 dy 3rd Current				10,000
	10	Sold to Lieutenant Goodwyn Exc: Engr Stn 10th Gauges Canal				
		40 Side Fill Wagons Complete — @ 100/1. ea		4,000	" "	
		Percentage for Wear and tear 1/10th — @ 10/1 p Cent		400	" "	4,400
	15	Cashed the Directors Draft No: 1 of 1852/53				10,000
	20	Bought from the Monkland Iron Company. for Cash				
		1000 Mds Bar Iron (Various) — Stock Book Page 1 @ 5/1 p Md.				5,000
	25	Sold for Cash, to Nyclul, a Carpenters Chest of Tools		100	" "	
		Per Centage — @ 10/1 p Cent		10	" "	110
	31	Lieut. Goodwyns' Bill to Current Repairs to Buildings				1,000
		Received from the Warehouse for the use of the Shops				
		1 Carpenters Chest of Tools		100	" "	
		1 Smiths do		50	" "	150
		Expended during the Month. As per Abstract Book				
		10 Brick Making Machines. Completed and sent to Warehouse				
		Iron		2,000	" "	
		Timber		1,000	" "	
		Manual labor		3,000	" "	
		Steam Engine do		2,000	" "	8,000
		10 Pile Engines — in progress.				
		Iron		1,000	" "	
		Timber		1,000	" "	
		Manual labor		500	" "	
		Steam Engine labor		500	" "	3,000
		Cost of Repairs and working Steam Engine				
		Labor		90	" "	
		Iron		10	" "	100
		Cost of labor during May 1852 — as per pay Book.				3,590
		Cost of Permanent Establishment for May as per pay book				1,000
		Percentage for Wear and tear of Tools @ per cent				500
		Interest on Value of Dear Stock @ 5 per cent				500
						1,14,350

Journal

Dr.			Cr.			Folio of ledger
Rupees				Rupees		
80,000	" "	Dead Stock				
20,000	" "	Machinery and Tools	Government of India	130000	" "	1
20,000	" "	Raw Materials				
10,000	" "	Manufactured Goods				
10,000	" "	Bills Receivable	Government of India	10,000	" "	1
			Manufactured Goods	4,000	" "	3
4,400	" "	Lieutt. Goodwyn	Profit and Loss	400	" "	5
10,000	" "	Cash	Bills Receivable	10,000	" "	4
5,000	" "	Raw Material	Cash	5,000	" "	4
			Manufactured Goods	100	" "	3
110	" "	Cash	Profit and loss	10	" "	5
1,000	" "	Profit and Loss	Lieutt Goodwyn	1000	" "	4
150	" "	Machinery and Tools	Manufactured Goods	150	" "	3
			Raw material account	3,000	" "	2
8,000	" "	Manufactured Goods	Labor "	3,000	" "	6
			Steam Engine working "	2,000	" "	5
			Raw material account	2,000	" "	2
3,000	" "	Manufactured Goods	Labor "	500	" "	6
			Steam Engine working "	500	" "	5
			Labor account	90	" "	6
100	" "	Steam Engine Working account	Iron as	10	" "	2
3,590	" "	Labor account	Cash	3,590	" "	4
1,000	" "	Profit and Los	Cash	1,000	" "	4
500	" "	Profit and Loss	Machinery and Tool account	500	" "	2
500	" "	Profit and Loss	Government of India	500	" "	1
1,71,350	" "			1,71,350	" "	

Ledger.

Dr. The Government of India 6

Date			Folio	Amount	Date			Folio	Amount
1852					1852				
May	31	To Balance	6	140,500 " "	May	1	By Stock	1	130,000
						5	-"- Cash	1	10,000
						31	-"- Interest on Dead Stock	1	500
		Total		140,500 " "			Total		140,500
					June	1	By Balance		140,000
4		13½	2	4	4		13½	2	4

Dr. Dead Stock C

Date			Folio	Amount	Date			Folio	Amount
1852					1852				
May	1	To Value of	1	80,000 " "	May	31	By Balance	6	80,000
June	1	To Balance		80,000 " "					
4									

Dr. Machinery and Tools Cr.

Folio	Amount			Date		Folio	Amount		
				1832					
1 To Value of	1	20,000	" "	May 31	By Profit and Loss	1	500	" "
" do	1	150	" "		" Balance	6	19,650	" "
Total		20,150	" "		Total		20,150	" "
1 To Balance		19,650	" "					

Raw Material Cr.

Folio	Amount			Date		Folio	Amount		
				1832					
1 To Value of	1	20,000	" "	May 21	By Manufactured Goods	1	3,000	" "
" purchase Monkland Cy	1	5,000	" "		" do	1	2,000	" "
					" Repairs Steam Engine	1	10	" "
					" Balance	6	19,990	" "
Total		25,000	" "		Total		25,000	" "
1 To Balance		19,990	" "					

Dr. Manufactured Goods Cr.

Date			Folio	Amount	Date			Folio	Amount
1852					1852				
May	1	To Value of	1	10,000 " "	May	10	By Sales Ledger	1	4,000
		" do Additions	1	8,000 " "		25	" do Mychael	1	100
		" do do	1	3,000 " "		31	" do to Shops	1	150
							" Balance	6	16,750
		Total		21,000 " "			Total		21,000
June	1	To Balance		16,750 " "					

Dr. Bills Receivable Cr.

Date			Folio	Amount	Date			Folio	Amount
1852					1852				
May	15	To Directors Draft	1	10,000 " "	May	15	By Cash	1	10,000

Lieut. Goodwyn Ex. Engr. Am. Dist. Ganges Canal — Dr.

Date		Folio	Amount		Date			Folio	Amount	
					1852					
10	To Sundries	1	4,400	" "	May	31	By Work performed	1	1,000	" "
							" Balance	6	3,400	" "
	Total		4,400	" "			Total		4,400	" "
1	To Balance		3,400	" "						

Cash — Cr.

Date		Folio	Amount		Date			Folio	Amount	
					1852					
15	To cash for Directors draft	1	10,000	" "	May	20	By Monkland Compy	1	5,000	" "
25	" do Sales	1	110	" "		31	" Labor	1	3,590	" "
							" Salaries	1	1,000	" "
							" Balance	6	520	" "
	Total		10110	" "			Total		10,100	" "
1	To Balance		520	" "						

Dr. Profit and Loss Cr.

Date		Folio	Amount	Date		Folio	Amount
1852				1852			
May	31 To Repairs Buildings	1	1,000 " "	May	10 By Manufactured Goods	1	100
	" Permanent Establishm.t	1	1,000 " "		" Ditto	1	10
	" Percentage on Tools	1	500 " "		" Balance	6	2590
	" Interest on Dead Stock	1	500 " "				
	Total		3,000 " "		Total		3,000
June	1 To Balance		2590				

Dr. Steam Engine (Woking Account) Cr.

Date		Folio	Amount	Date		Folio	Amount
1852				1852			
May	31 To Repairs, attendance, &c."	1	100	May	31 By Manufactured Goods	1	2,000
	" Balance		2,400 " "		" Do	1	500
	Total		2,500 " "		Total		2,500
				June	1 By Balance		2,400

N.B. In actual practice it has been found better to carry the P
On this account to meet the Charges for Wear and tear of Machin

Dr. Labor Account Cr.

		Folio	Amount	Date		Folio	Amount
				1832			
31	To Cash	1	3,590 " "	May 31	By 10 Brick Machines	1	3,000 " "
					" 10 Pile Engines	1	500 " "
					" Steam Engine	1	90 " "
	Total		3,590 " "		Total		3,590 " "

Dr. Balance Sheet Cr.

				1832			
31	To Dead Stock	1	80,000 " "	May 31	By Profit on working Steam Engine	5	2,400 " "
"	Value of Machinery & Tools	2	19,650 " "				
"	do Raw Materials	2	19,990 " "				
"	do Manufactured Goods	3	16,750 " "		By Balance - being net Capital	1	140,500 " "
"	Due from St. Coodwyn	4	3,400 " "				
"	Cash in hand	4	520 " "				
"	Profit and Loss	5	2590 " "				
	Total Liv: Pt		142,900 " "		Total Liab: Pt		142,900 " "

No: 26. November 1833

Wheelbarrows for Lieutenant Dyas

Quarters	Rate	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
adier	9/	"	9	9	9	9	"	9	9	9	9	9	9	"	9	9	9	9	9	"	9	9	9	9	9	9	9	"	9	9	9	"		225
le 1/	9/	"	9	9	9	9	"	9	9	9	9	9	9	"	9	9	9	9	9	"	9	9	9	9	9	9	9	"	9	9	9	"		225
die	9/	"	9	"	9	9	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	9	9	9	"	9	9	9	"		81
	9/	"	9	9	9	9	"	9	9	9	9	9	9	"	9	9	9	9	9	"	9	9	9	9	9	9	9	"	9	9	9	"		225
ew 13/	9/	"	9	9	9	9	"	9	9	9	9	9	9	"	9	9	9	9	9	"	9	9	9	9	9	9	9	"	9	9	9	"		225
dew 12/	9/	"	9	9	9	9	"	9	9	9	9	9	9	"	9	9	9	9	9	"	9	9	9	9	9	9	9	"	9	9	9	"		225
	9/	"	9	9	9	9	"	9	9	9	9	9	9	"	9	9	9	9	9	"	9	9	9	9	9	9	9	"	9	9	9	"		225
	9/	"	9	9	9	9	"	9	9	9	9	9	9	"	9	9	9	9	9	"	9	9	9	9	9	9	9	"	9	9	9	"		225
ua	9/	"	9	9	9	9	"	9	9	9	9	9	9	"	9	9	9	9	9	"	9	9	9	9	9	9	9	"	9	9	9	"		225
ka	9/	"	9	9	9	9	"	9	9	9	9	9	9	"	9	9	9	9	9	"	9	9	9	9	9	9	9	"	9	9	9	"		225
	9/	"	9	9	9	9	"	9	9	9	9	9	9	"	9	9	9	9	9	"	9	9	9	9	9	9	9	"	9	9	9	"		225
abonnes	9/	"	9	9	9	9	"	9	9	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"		54
Total		"	108	99	108	108	"	99	99	99	90	90	90	"	90	90	90	90	90	"	90	90	90	90	99	99	99	"	99	99	99	"		2385

6/2 2 1½ 1½ 1 — — — 2

Dy. Comds

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Form 8.

Stock Book.

Dead Stock the Prope

Buildings

Interest at 5 pe
of 5 per Cent C
to Governme

1st May 1852. 2d

[To be detailed in such manner that the description of Rooms, Number, & Measurements &c. may at any time be known]

4

50,000 . . 31st May 1852 3

It will be understoo
noted without regard to
of the Day Book.
for this is only given
Record of Original Dedi

Government of India. Roorkee Factory

Steam Engines.

				Interest at the rate of 5 per cent credited to Government.				
1st May 1852 22½								
To be detailed in such manner that the principal parts may be recognized	4 Rupees 30,000	"	"	8 31st May 1852	4 Rupees 200	"	"

dates and Amounts of Interest are
ry. and only to preserve the order
form also may be improved upon
ation of what is required to fix the

Dr. "

Machinery and

Date		Description	Amount		Post
1852 May	4	26		4	4
		I Received from Lt. A. S. Goodwyn Ex: Engr. St. Dr. Ganges Canal			
		1 5 inch centre Holtzapffels Lathe &c. &c.	2,000	"	"
		2 do do &c. &c. @ 2,000/-	4,000	"	"
		Punching and Shearing Machine	1,000		
		50 Anvils @ 20/-	1,000	"	"
		50 Carpenters Chests of Tools @ 100/-	5,000	"	"
		50 Smiths do @ 50/-	2,500	"	"
		50 Forge Bellows @ 10/-	500	"	"
		500 do Hammers @ 2/-	1,000	"	"
		100 Dozen Files as below @ 5/-	500	"	"
		25 Doz: Smooth Round 8 in			
		25 " Half " 8 in			
		25 " " Bottam 6 in			
		25 " " Safe edge 10 in			
		500 Smiths Beck Irons @ 2/-	1,000	"	"
		Screw Augurs as below			
		2 Doz: long Screw with eyes 1/2 @ 20/-	40	"	0
		2 " " 3/4 @ 25/-	50	"	0
		2 " " 1 @ 30/-	60	"	0
		5 " " 1 1/2 @ 40/-	200	"	0
		4 " " 1 1/2 @ 50/-	200	"	0
			550	"	"
		50 Hand Vices @ 5/-	250	"	"
		50 Best Turkey Stones @ 10/-	500	"	"
		1 Grindstone	200	"	"
					20,000
May	31	Received from Warehouse			
		1 Carpenters chest of Tools	100	"	"
		1 Smiths do	50	"	"
					150
		Total Company's Rupees			20,150
1852 June	1	To Balance			19,650

Consumed and used in the Factory ____ Dr.

Date		Description	Amount	Total
		2	4	4½
May	31	By percentage of Wear and tear charged to Profit and Loss.		500 " "
	"	By Balance		19,550 " "
		Total Comp'y Rupees		20,150 " "

N.B. This account Current is for the Office. The Store Keeper would keep his Stock in a Tabular form. enabling the authorized person in the Offic to his initials to any thing written off that may have been condemned as unserviceable.

Dr. _____ Iron

Date		Description	Amount	Total
1852 May	1	Received from Lt. A. G. Goodwyn Ca: Eng[rs] & Sup[t] D[o] Gauges Canal		
		100 Bars Rolled Iron 1½ in:	lbs.	Ds.
		100 " " " 1¾		100 " 0 " 0
		100 " " " 3		100 " 0 " 0
		200 Bolts " " 7/8		200 " 0 " 0
		500 " " " 1		200 " 0 " 0
		500 Bars Angle Iron 1 x ⅞		500 " 0 " 0
		400 " " " 1½ x ⅞		500 " 0 " 0
		Total Lbs — 2,000 " 0 " 0 @ 5 // ₱ Mo		400 " 0 " 0
			10,000 " "	10000
20		Bought from the Monkland Iron and Steel Company as per Invoice of this date —		
		500 Bars Rolled Iron 1½		500 " 0 " 0
		500 " " " 2		500 " 0 " 0
		Total Lbs — 1,000 " 0 " 0 @ 5 // ₱ Mo	5,000 " "	5,000
		Total Company's Rupees		15000
June 1852	1	To Balance		11,990
		Detail of Stock to be given with rates.		

Account. 6

Date		Description	Amount	Total
1852				
May	31	Issued to Works during the Month as per daily Abstract and as per Store Keepers account		3010 " "
		By Balance		11,990 " "
		Total Company Rupees		15,000 " "

Here again this account is merely for the Office. The Store Keeper must keep his in a Tabular Form with all detail. Form for this is appended. and the same form will answer for all the Store Keepers, if there are more than one.

Dr. Jim

Date		Description	Amount	Total
1852 May	1	Received from Lieutt Alg Goodwyn Ca: Cug: Mt Dn 1st Cavalry		
		Detail Articles as in Sun account		10,000
		Total Company's Rupees		10,000
1852 June	1	To Balance		8,000
		Detail		

Account _____ Cr.

Date		Description	Amount	Total
1852				
May	31	Issued to Works as per daily Abstract and as per Store Keepers account	Rupees	Rupees 2,000 " "
		By Balance		8,000 " "
		Total Company's Rupees		10,000 " "

See remarks to Iron account

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16
14
2
9
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7 12

Dr. Manufactures

Date		Description	Amount	Total
1832 May 4	1	Received from Lt. Alglood 26 nye Ex: Engr. Nr. Dr. Ganges Canal	4	
		(Detail articles as in Store Account.)		10,000
May	31	10 Brick Making Machines @ 800/@	8,000 ..	
		10 Pile Engines in progress	3,000 ..	11,000
		Total Company's Rupees		21,000
1832 June	1	To Balance	16,750 ..	

...ods Account _____ Cr.

Date		Description	Amount		Total	
1932						
Jany	10	By Sales to L. Goodwyn _____	4,000	" "		
		" " to Mychul Carpenter _____	100	" "		
		" issues to Workshops _____	150	" "	4,250	" "
		By Balance _____			16,750	" "
		Total Company Rupees _____			21,000	" "

The Warehousemaw should also keep his own account in a Tabular form - so that on the receipt of Orders he can at once tell by reference to it whether he has the article in store or not -

APPENDIX

M

Sig 2k

Appendise Ganges Canal

Sig 10 10-2

Vol III

List of Books belonging to the Ganges Naval Professional Library on the 1st of April. 1854.

299 lines

(1)

Names of Books	No. of Vols.	Size.
Atis Data	1	8vo.
ais High Pressure Steam Engine	2	do.
ais Astronomical Essays	1	do.
thong on Boilers	1	do.
raical Geometry (Library of useful knowledge)	½	do.
ralty manual of Scientific Enquiry	1	do.
and Orders 1840-43	1	4to.
Land Magazine of Natural History	6	8vo.
is Collodion Process	1	do.
tectures Building and Carpentry (Encyclopedia Britannica)	1	4to.
ican Machinery, Drawings of	1	Fol:
Memoirs of the Military Sciences	3	8Vo.
nus' Agricultural Engineering	1	p Octavo.
nis Great Western Railway	1	Imp.
London and Birmingham Railway	1	Imp.
ni's Cours d'Eau	2	8vo.
Traité's des Irrigations	3	do.
——— Do. ——— Do. ——— Plates	1	Obl. 4to.
hanan's Mill Work	1	8Vo.
Do and examples of Modern Tools	1	4to.
Do Do Do Atlas	1	Imp:
d on Arches	1	8Vo.
more's Hydraulic Tables	1	8Vo.
on the improvement of River Navigation	1	8Vo.
Railway Practice	4	4to.
g Jones' Canal Reports N.W.P.	1	Fcp.
ut et Viallet sur les digues	1	4to.
ts Hydrodynamics	2	8Vo
Plates of the Main	1	4to
ni's Lectures on Iron Suspension Bridges	1	8Vo
——— Do. ——— Do. ——— Do.	1	do
der, The - 1843 - 1851	9	R 4to
's Grammar of Philosophy	1	12mo
ages Economy of Manufactures	1	p 8Vo
dis Dictionary of Science, Literature and Arts	1	8Vo
ni's Encyclopedia of Arts, Manufactures & Machinery	1	4to
on Materials	1	8Vo
ni's Practical Model Calculator	1	do
hanan on Tools and Machines	1	R 8vo
——— Do. ——— Do. ——— Plates	1	Fol.
on the Screw Propeller	1	4to
tts Geometrical Illustrations	1	4to
dis Manual of Chemistry	2	8Vo
olemew's Specifications for Architecture	1	do
der - 1852	1	R 4to

Names of Books	Vol
Brooks Designs for Cottage and Villa Architecture	1
Burnetts Patent Process of Preserving Timber &c.	1
Brandon's Parish Churches	2
Barlow on Materials	1
Clarke's Britannia and Conway Bridges	2
Do Do Do Plates	1
Cauley's Reports on Canals N.S.W.	1
Craig's Lectures on Drawing	1
Crey's Encyclopædia of Civil Engineering	1
Civil Engineer's and Architect's Journal 1838-1851	14
Do Do Do 1843 and 1844	2
Civil Engineers Institution, Transactions of	3
Conversations on Chemistry	1
Calcutta Journal of Natural History	8
Civil Engineer's and Architect's Journal 1852	1
De Bettani Travaux Hydrauliques	2
Dixon's Mainwaring	1
Davy on Foundations	1
Drewry on Suspension Bridges	1
De Morgan's Calculus (Library of useful Knowledge)	1
Della Condotta delle Acque (Romagnosi)	1
De la Landes Canaux de Navigation	1
Dempsey's Iron and Brick Bridges and Iron Roofing	1
Do Do Do Plates	1
Directions to Collectors of Land Revenue 1848	1
Dubuats Hydraulics	1
Do Do	1
Douglas on Naval Gunnery	1
Dana's System of Mineralogy	1
Do Manual of Do	1
De la Rive on Electricity Vol. 1.	1
Downing's Architecture of Country Houses	1
Daniell's elements of Meteorology	2
Delabeche's Geological Observer	1
Everests measurement of the Meriodional Arc of India	1
Do Do Do Plates	1
Elmes Metropolitan Improvements	1
Ewbanks Hydraulic Machinery	1
Elliots Practical Geometry (Oblong)	1
Fox's Artistic Anatomy	1
Do Do Atlas	1
Forget Electricity and Animal Physiology	1
Fumis Laghi e Canali di Milano	1
Frome's Trigonometrical Surveying	1
Fulton on Canal Navigation	1
Ferguson's Mechanics	1
Do Lectures on Do	1
Gwilt on Arches	1
Do Architectural Criticisms	1
Graham's Elements of Chemistry	1
Gauthey's Canaux de Navigation	1
Goodwyn's Memoir on Cast Iron Roofing	1

Names of Books (2)	No. of Vols.	Size.
ay's Mathematics for Practical Men	1	8Vo
ic Ornaments of Lavenham Church	1	4to
aphy of Architecture	2	8Vo
ts Outlines of Comparative Anatomy	1	do
ce, Antiquities of	2	do
low's Botany	1	do
ers' Principles of Geography (oordoo)	1	do
ins on Cements	1	do
s on Road Making	1	do
is Canal de Jonction de la Meaute au Rhin	1	4to
Do Do Plates (Godfrey)	1	Royal
Hors East Indies Gazetteer	2	8Vo
Do Do	1	do
apfells Turning and Mechanical Manipulation	3	8Vo
on Form	1	4to
kins on on cast Iron	1	8Vo
ells Outlines of Astronomy	1	do
Natural Philosophy	1	Foap do
is Recreations	4	8Vo
boldts Cosmos (vol 1)	1	do
ris. Report on Ventilation	1	do
tution of Civil Engineers 1844/5/6/7 and 1849/50	5	do
ons Physical Atlas (1846-47)	1	Imp
ons Military Surveying	1	8Vo
Report on the Portonville Prison 1844-46	1	Foap
on Annuities (Library of Useful Knowledge)	2	8Vo
Roof of new Houses of Parliament	1	4to
ans Register of Medical Science	1	8Vo
nal of Asiatic Society of Bengal	9	8Vo
Agricultural Society of India	3	do
and Landners Mechanics	1	do
L'Art de la Charpente	1	Imp
is Chemical Technology	3	8Vo
tures (Faraday's) on the Non-metallic Elements	1	Foap do
is Inland Navigation	1	8Vo
gs Letters on Chemistry	1	do
Agricultural Chemistry	1	do
unt on Railways	1	8Vo
ley's Botany (Library of Useful Knowledge)	1/2	do
is Traite de Geometrie Descriptive	1	4to
on and its Environs Topographical and Geological 1857	1	8Vo
ers Flords in Moray	1	8Vo
ons Encyclopadia of Gardening	1	do
ners Railway Economy	1	Foap 8Vo
is Elementary Geology	1	8Vo
Principles of Do	1	do
ngtons Mechanical Philosophy	1	do
ey's Illustrations of Mechanics	1	do

1 Tailor @ 1/9½ = 8.8.0

Names of Books	No. of Vols.
Moseley's Mechanics applied to the Arts	1
Do Engineering and Architecture	1
Millers Principles of Physics and Meteorology	1
Do Science of War	1
MacNeils Earthwork Tables	1
Martins Circle of Mechanical Arts	1
Mahans Civil Engineering	1
Mathematics (Library of Useful Knowledge)	2
Mechanics Magazine	10
Murays Encyclopedia of Geography	2
Mushet on Iron and Steel	1
McCulloch's Commercial Dictionary	2
Do Geographical Do	2
Mitchells Patent Screw Piles and Moorings	½
Naval Dry Docks of the United States	1
Naviers Memoire sur les Ponts Suspendus	1
Do Do Do Plates	1
Notes on building and road making	1
Nicholsons Principles of Architecture	3
Do Architectural Dictionary	2
Nichols Architecture of the Heavens	1
Natural Philosophy (Library Useful Knowledge)	4
Do Do Do	4
Nautical Almanac for 1836-38 and 1842-46	6
Naturalists Library (Animals)	13
Do Do Birds	4
Overmans Manufacture of Iron 1850	1
Do Do 1851	1
Do Do Steel	1
O'Shaughnessy's Bengal Pharmacopoeia	1
Overmans Mineralogy	1
Do Moulders and Founders Guide	1
Peschels Elements of Physics	3
Plattner on the Blow-pipe by Muspratt	1
Professional Survey of old and new London Bridges	½
Paleys Baptismal Fonts	1
Philips's Inland Navigation	1
Do Manual of Metallurgy	1
Philpotts Report on the Canal Navigation of the Canadas	1
Parnells Treatise on Roads	1
Papers prepared for the use of E.E. College Roorkee. Parts 1 & 2	2
Perronet sur les Ponts	1
Do Do Plates	1
Pugin and Britton's Public Buildings of London	2
Pugin's Examples of Gothic Architecture	3
Do Do Do Ornaments	1
Pugin and Mackenzies Specimens of Gothic Architecture at Oxford	1
Pambour on the Steam Engine	1
Pococks Finishings	0

(3)

Names of Books	No. of Vols.	Size.
ington on the Steam Engine	1	8 Vo
ional Papers of the Royal Engineers	2	R 4 to
ical Geometry (Library of Useful Knowledge)	1	8 Vo
o and Spherical Geometry (Do)	1	do
ys Practical Geometry	1	do
ley on Lime and Cements	1	do
on Measures Weights and Money	1	do
Military Policy	1	do
t on Chemistry and Digestion	1	do
Elements of Chemistry	1	do
att on the Microscope	1	do
tely Journal of Literature, Science and Arts	3	do
ue Meteorological Statements N.W.P. 44/45 to 49/50	1	4 to
t on the Boundary between Guntoor & Masulipatam 1850	1	8 Vo
tto D'Autori delle Acque	6	do
ung Surveyor's Receptor	1	4 to
il de Divers Memoirs, Extraits de Bibliotheque Imperiale	2	Demy 4 to
des Ponts et Chaussées	1	Fcap
on the Harbours of Refuge to be Constructed at Dover & Holyhead	2	do
t on the Caledonian Canal	1	do
Select Committees: On Westminster Bridge & New Palace	3	do
On Metropolitan Improvements	1	do
On Do Railways	1	do
On Light Houses	1	do
On the Highways of the Kingdom	1	do
On Shipwrecks	1	do
on Grand Trigonometrical Survey of India	1	4 to
of Nizamut Adalut of 1842/43	7	8 Vo
on Public Instruction N.W.P. 1845/46 to 1851/52	6	do
Do Do Lower Provinces 1845/46-1850/51	1	do
er of Do Do 1835-51, part I by J Kerr M.A.	1	4 to
t on Revenue Administration 1848/49	1	8 Vo
ts Electricity (Library of Useful Knowledge)	½	do
on Animal & Vegetable Physiology	2	do
ree College of Civil Engineers, Account of	1	Fcap
of Venice, Rusteni's	3	4 to
Lamps of Architecture do	1	do
his celestial Cycle	2	8 Vo
son on Marine & River Surveying	1	R 8 Vo
on Mathematical Instruments	1	8 Vo
ens' Book of the Farm	2	R 8 Vo
Professional Papers of the Madras Engineers	1	Demy
ris Reports	4	4 to
Eddystone Lighthouse	1	Roy
School of Arts	2	8 vo
s on Levelling	1	do
th on Isometrical Drawing	1	do
Mechanic	2	do
and Thuillier's Manual of Surveying in India	1	do
ndon on Locomotives	1	4 to
il Engineering in North America	1	8 Vo

W. Allen

1st Taken @ 1/9½ = 5.8.0

Names of Books.	No. of Vols.	
Long's Essay on the Solution of Algebraic Equations	1	
Semple's Building in Water	1	
Sturgeon's Lectures on Galvanism	1	
Switzer's Hydraulics, 1729	1	
Stewart's Planter's Guide	1	
Smith on watering Meadows	1	
Settlement Miscellaneous 1847	1	
Do Do Do	1	
Strickland Gill and Campbells Public Works of the U. S. America	1	
Do Do Do Plates	1	
Stuart and Revetts Athens	4	
Smith's Animal Physiology (Library Useful Knowledge)	½	
Sinclairs Planting (Do)	½	
Selections from Public Correspondence. Pont X	1	
Smith's Italian Irrigation	2	
Do Do Atlas	1	
Standing Orders Do. P. W.	3	
Somerville's Physical Sciences	1	
Turnbull's Essay on Cast Iron beams	1	
Tredgold on Cast Iron	1	
Do on the Steam Engine & Steam Navigation	2	
Do Do Plates	2	
Do elementary principles of Carpentry	1	
Tielke's Field Engineer	2	
Tatham and Smith on Irrigation	1	
Telford, Sir Thomas, Life of	1	
Do Do Atlas	1	
Theory of Equations (Library of Useful Knowledge)	½	
Transactions of the Bombay Geographical Society	1	
Templeton's Work Shop Companion	1	
Ures Dictionary of Arts and Manufactures 1846	1	
Do Do Do Supplementary 1851	1	
Vicat on Cements	1	
Weales Papers on Civil Engineering	5	
Do Examples of Railway making	1	
Do. Theory, Practice and Architecture of Bridges	1	
Do Do Do Plates	2	
Do Public Works of Great Britain	1	
Do Architectural Drawing Book	1	
Do Do Do Plates	1	
Whitlaw and Stuarts Water Mill	1	
Whewells Mechanics	1	
Do History of the Inductive Sciences	3	
Do Philosophy of Do Do	2	
Do Astronomy and Physics	1	

(4)

Names of Books.	No. of Vols.	Size.
Bach's Mechanics of Machinery	2	8vo
Billings Traité sur la construction des ponts	1	4to
Do Do Do	1	do
Do Do Do Plates	1	Imp
Clarks Railways of Great Britain & Ireland	1	do
Cys Principles of Mechanics	1	8vo
Davis Diana Antigua	1	4to
Webster English Dictionary	1	do
Jones Hand Book of Mapping	1	do

Imp. Paper @ 1½d = 5.8.0

List of Books belonging to the Non. Professional Li=
y of the Ganges Canal on the 1st of April
4.

(3)

Canvr

Names of Books.	No. of Vols.	Sizes.
calypse Revealed, by Swedenborg	2	pl 4to
and Gospels in Bordeo	1	8vo
istian Philosopher by Dick	1	do
on the Origin of, by Archbishop King	1	4to
leading doctrines of the New Church	1	8vo
en and Hell, by Swedenborg	1	pl 4to
duction to the Bible, Horne's	1	8vo
ural Theology, by Paley	2	12mo
Do. Do.	2	8vo
Jerusalem, by Swedenborg	1	pl 4to
ical Evidence of a future life, by Butterworth	1	do

History and Biography

ens, its rise and fall, by Bulwer	2	8vo
hanistan, Military Operations in	1	do
in Spain under Sir. John. Moore	1	do
al Biography and Obituary for 1817 & 1823	2	do
phical History of Ancient and Modern Philosophy	2	12mo
h Jurg. History of the, Whyte's	2	12 4to
costume, History of, Planche's	1	12mo
commerce, Do, by G. L. Craik. A.M.	1	do
apoate, his sayings and doings, by A Vieusseaux	1	do
the Traveller, Life of, by Major Head	1	do
an, Life of, Southey's	1/4	8vo
on, Sir. J. F. Burt, Memoirs of, by his Son	1	8vo
h Army at Washington and New Orleans by Gleig	1/2	do
al, History of, Marshmans	1	pl 8vo.
h, History of the (Library of Useful Knowledge)	1	8vo
ation in Europe, History of Guizots	1	do
on, Life of	1/2	12mo
Lord, Do. by Gleig	1	8vo
well, Life of, Southey's	1/4	do
ie, Do, Lord Mahon's	1	do
pher Columbus, Life & Voyages of, W Irving's	2	do
ton Captain Memoirs of	1	pl 8vo
an, Memorials of, Peake's	2	pl 4to
War of Rome	2	12mo
ts Portrait Gallery of British Worthies	6	12mo

Cancr 473 lines

Cancr 1/2 = 5. 5. 0

Names of Books	No. of Vols.
Cromwell, Protectorate of, Vaughans	2
Cowper, Life of	1
Caulincourt, Duke of Vicenza, Recollections of	2
D'Arblay, Madame, Diary of	3
Dibdin, Thomas, Reminiscences of	2½
Drake, Life of	3
England, History of, Hume and Smollett 1835	2
Do Do, Vaughan, (Library of Useful Knowledge)	1
Edgeworth, the Abbé, Memoirs of	2
Edgeworth, R. L. — Do	1
Franklin Benjamin, Autobiography of, by J Sparkes	1
France, History of (Library of Useful Knowledge)	1
Do — Do — Gifford	2
French Revolution, History of, Carlyle's	3
Greece, History of, (Library of Useful Knowledge)	1
Girondists, Do, Lamartine	3
Gresham, Sir T, Life of, Macfarlane's	½
Goldsmith Oliver, Life of by W Irving	1
Do — Do — Do	1
George the Second, Memoirs of the Reign of, by Lord Henry	2
Gibralter, Siege of, Duntwaters	½
Grammont, Count, Memoirs of	3
Hindostan, History of, Dow's	3
Historical Essays by Lord Mahon	1
Do Parallels, by A. Malkin M A	1
Haydn's Dictionary of Dates	1
India, History of, Elphinstones	2
Johnson, Doctor S, Life of Boswell's	4
Jefferson Presidents, Memoirs of	1
Impey, Sir Elijah, — Do —, by his Son	1
Josephus, Whiston's	2
Literature of Greece, History of (Library of Useful Knowledge)	1
London, History of, Mackay's	1
Literature of England, History of	3
Louis XVIII, Life of, written by Himself	1
Louis Philippe, Life and times of, Wright's	2
Lives of the early Italian Painters	1
Do of Eminent Persons (Lib: Usef: Know:)	1
Louis XIV and the court of France by Miss Pardoe	3
Lafarge, Madame, Memoirs of	1
Mammalia, History of the	3
Monkeys, History of	½
Mozart, Life of, by Holmes	1
Mahomet, Life of, by W. Irving	1
Memoirs of a working man	½
Munro, Sir T. Life of	1
Narative of the Insurrection at Benares	1
Do — Do — Do	1
Nelson, Life of, by Southey	1
Ney Marshal, Memoirs of	1

Names of Books.	No. of Vols.	Size.
Chens Campaigns of 1812-13	2	8vo
leon's Expedition to Russia, by Count Segur	2	do
al Christian Biography	3	do
, History of, Cabinet Cyclopedia	1	do
ting, History of, Women's	1	12mo
the Great, Life of	1	do
and its Historical Scenes	1	do
peii, its destruction and re-discovery	1	do
Musgrave or Missionary Life in Canada	½	8vo
a, History of (Cabinet Cyclopedia)	3	do
Secret History of, Schmitzer's	2	do
and Portugal History of (Lib: Useful Knowl:)	1	do
land — Do — (Do)	1	do
(Cabinet Cyclopedia)	1	do
lena, History of, Moore's	1	do
ors of Mahomet, Life of, Irving's	1	do
do, Military Operations in	1	do
ner, Colonel, C.B. Memoirs of	2	do
men of the time of Geo III, Brougham	3	12mo
ns from the Records of the Government of India, Sir C. Napier's resignation	1	4to
Brigade in Affghanistan, by Gleig	½	8vo
Years War, Schiller's	1	12mo
o, Two Sieges of, by the Turks	½	8vo
ies of the British Armies, Maxwell's	1	do
n Empire, History of, Carnegie's	12	R8vo
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With, Meinhold's, translated by Lady Duff Gordon	½	do
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Do — Do	2	do
r and Rock, by Miss Martineau	½	12mo
nan (Library of Romance)	1	8vo
Watch, Dickens	3	do
inister	2	do
, Cooper's	2	do
in Spain, Borrow's	1	do
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1 " " " Labor @ 1/3½ = 8.8.0

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Do Do Lees,	2
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Count Julian by Simms	1
Charlotte Corday by Miss Hendrick	1
Cid Dennis's	1
Crock of Gold, Tuppeis	1
Chronicles of the Bastille	1
Camp of Refuge by Macfarlane	1
Don Quixote	4
Deer Slayer, Coopeis	3
Dutch in the Medway	½
Emigrants of Ahadarra, Carleton's	1
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Do Do	1
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Last of the Barons	3
Do Do	3
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APPENDIX
N

Valuation Statements of Property a
Ironbridge, falling within the Canal
Boundaries

Meeru
Mexca
North
North Sc
Nature
Oregon
Origin
Permit
Purdue
Do
Popula
Philos
Penny
Princ
Plan
Quar
Repre
A Step
Sothern
Secret
Scinde
Sheep
Science
Text
Volum
Views
Wante
Wilder
Do

Lebensdauer bis o. J.

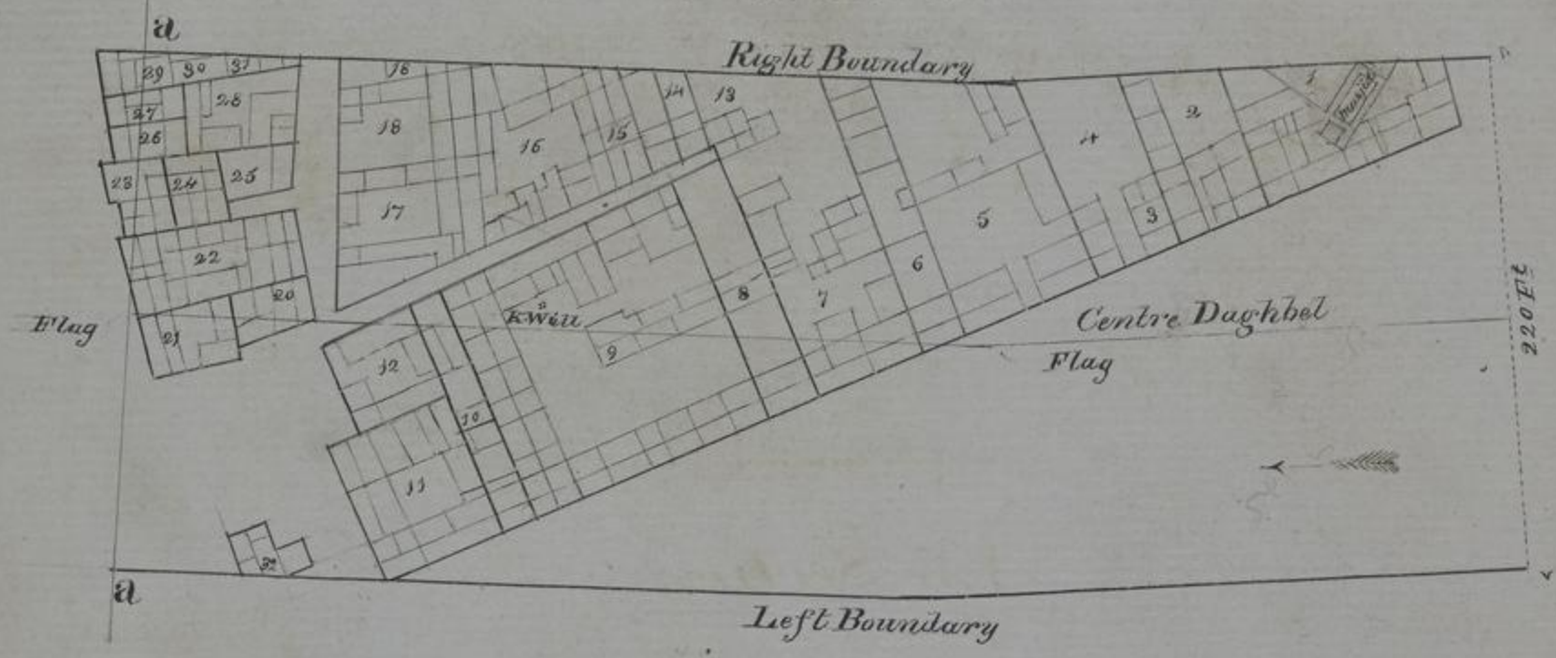
1 Wagenpferd à 9 M. pro Tag = 25 M. 7 Sgr. Futter à 1/3 M. = 8 T. 8 Sgr.

Appendix SY

PLAN

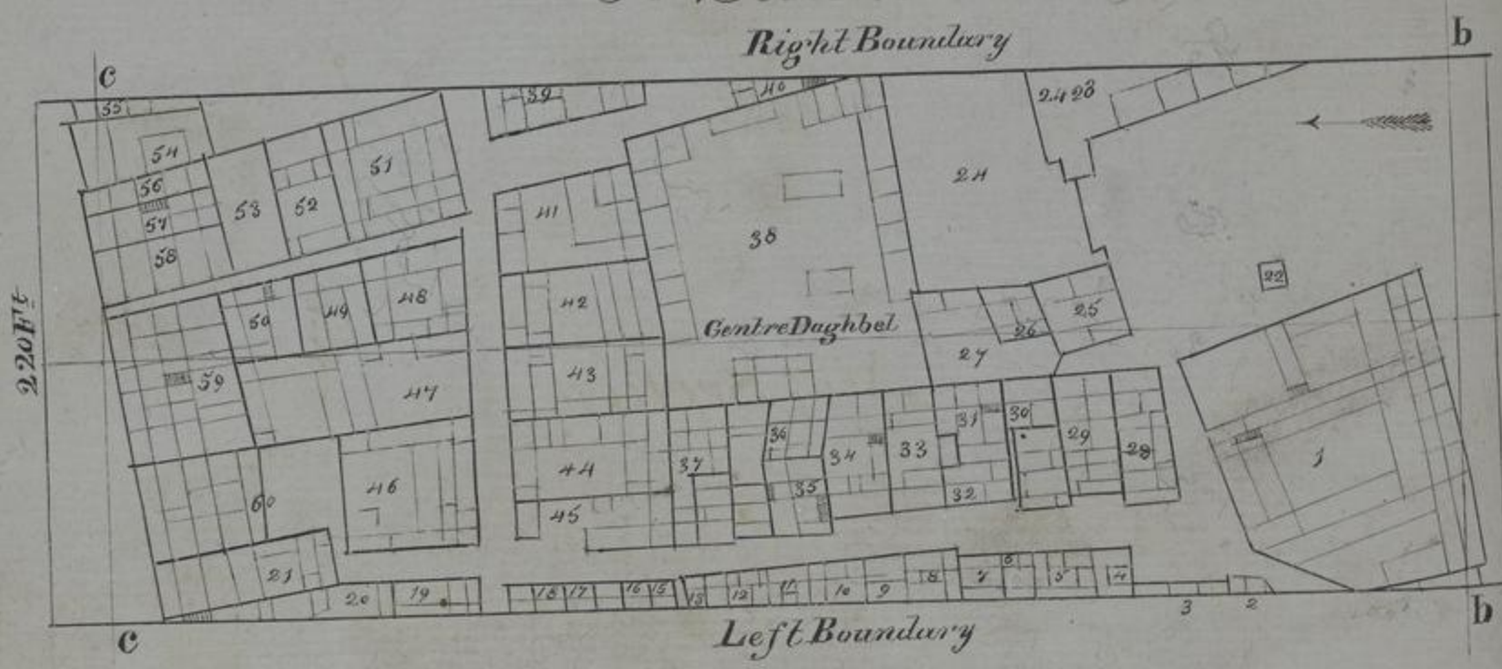
Shewing the Property included within the Line of the Ganges Canal in its passage through Cawnpoor

1st Section



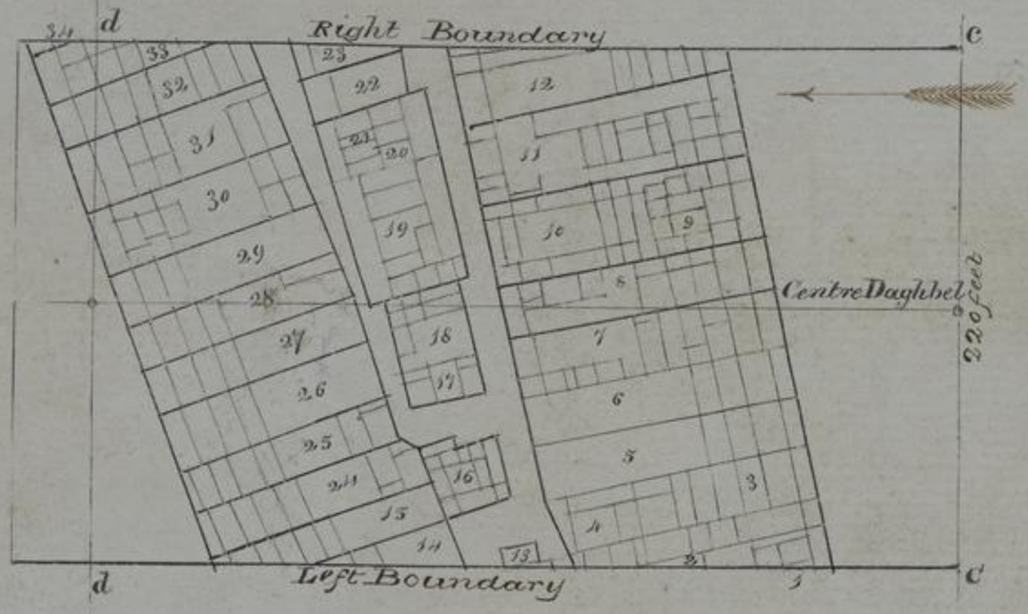
2nd Section

3rd Section



NB Thick Black Lines represent the Boundaries of the different Estates

No 4. Section



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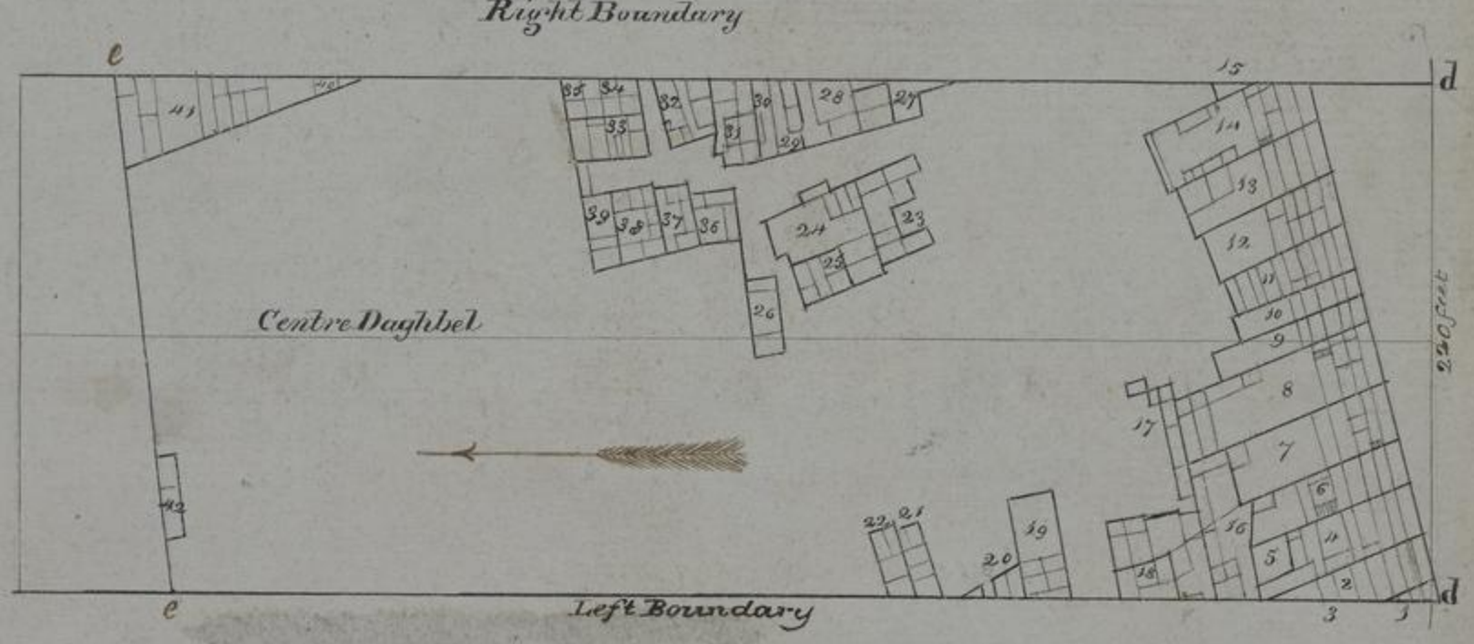

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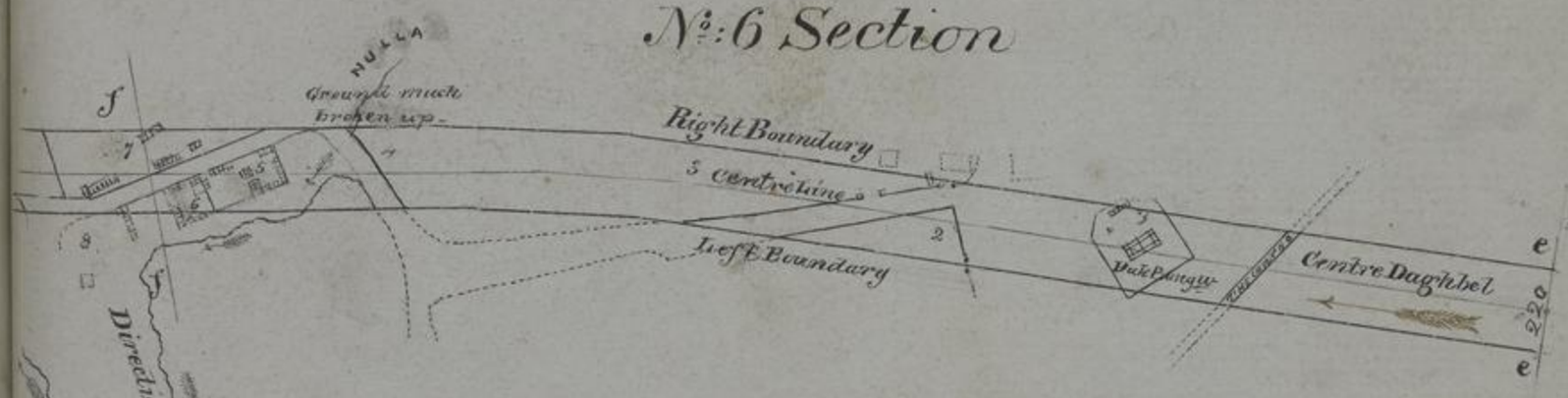

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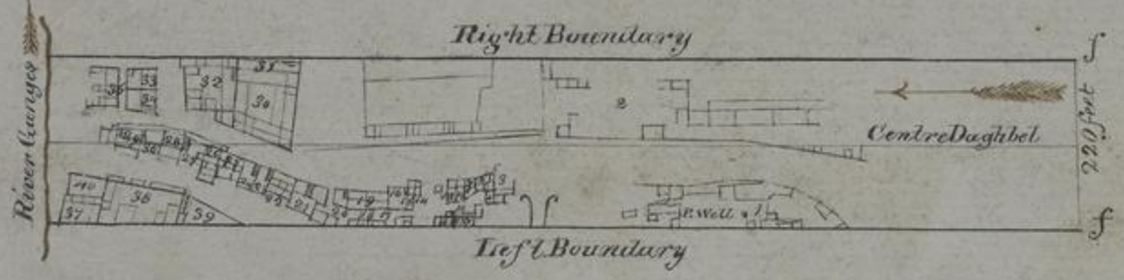

N.B. Thick Black Lines represent the Boundaries of the different Estates

1

and Valuate Certain
Bazar and Canton

through the Suddur

bruary 1851.—

Captain
Lieutena

ll—

Deputy Magistrate

Committee—

No:	Names of Valuation by C
1	Shoolamee Khan— (Valuation 208 "
2	Gungadeen— (Valuation 200 "
3	Siwa Ram— (Valuation 200 "
4	Muddun Mohun Valuation 550 " 0
5	Deoke Nundun— Nulcan— Valuation 65 " 0 " 0

t @ 8/. ℘ % = 139 " 3 " 2

erficial feet = 52 " 3 " 2

part of house ⅞ only to be

Labor @ 2/4/. ℘ % = 13 " 13 " 9.

℘ % = 40 " 0 " 0. labor at

℘ % and 3 for a

12/14/"

10/1. ℘ % = 163 " 12 " 9

Supplies @ 5/"/" ℘ % = 28 " 9 " 7. labor @ 1/2/" = 8 " 8 " 0

PLAN shewing by the Red lines the additional spaces of Ground taken up for the GANGES CANAL in the passage through CAWNPOOR

N°I BRIDGE

N°II BRIDGE.

N°III BRIDGE

N°IV BRIDGE

N°V BRIDGE

Oude Road

Copied by Mouldings Howard & Roberts

...ons and property which come in the line required for the Ganges Canal through the Suddur Bazar and Cantonments

— 1st Section — Cawnpoor 27th February 1861.

President Major G. Thompson

Captain G. R. Siddons, Lieutenant R. Wroughton } Members { Captain J. Riddell, Syud Nasir Alli Khan Deputy Magistrate

No:	Names of Valuation by Owners	Description	Remarks by the Committee
1	Khoolamee Khan — (Valuation 208.12.9)	15 Rooms average dimentions about 14½ by 8 feet. walls of 8 rooms of Kucha Pukka Masonry, remainder of mud. height of walls about 13 feet. roofs of 14 Kucha and 1 of Pukka. had, and remainder in pretty good order	Owner not present 1740 Sup.feet @ 8/.f.p/o = 139.3.2 — cost for labor @ 3/.f.p/o Superficial feet = 52.3.2
2	Gungadeen — (Valuation 200.0.0.)	7 Rooms average 11' by 8'. 5 Kucha roofs on wall 10' high. 2 tile roofs on walls 8½' high. walls of mud, front wall on pucka	Owner present 614 Sup.feet @ 11/.f.p/o part of house for'd only to be taken for Canal Line = 43.1.11 Cost of Labor @ 2/4/.f.p/o = 13.13.9.
3	Siwa Ram — (Valuation 200.0.0)	5 Rooms average 9½' by 8'. 4 kucha roofs on walls of mud 10' high. one roof of tiles. front wall of kucha Pukka masonry in good order.	Owner present 380 Sup.feet @ 10/8/.f.p/o = 40.0.0. labor at 2.0.0 per/o = 9.8.0
4	Muddun Mohun — (Valuation 550.0.0)	4 Rooms average 13½ by 8½', two roofs kucha on mud walls and two tile roofs Do 2 tiled sheds in rear of rooms.	Owner present 556 Sup.feet @ 10/.f. f.p/o and 3 for a well - in all 58/o/o labor @ 2/8/.f. = 12/14/.f.
5	Deoke Nundun — (Valuation 1200.0.0)	12 Rooms average 19½ by 7'. 4 kucha roofs on mud walls on of thatch and the rest of tile	Owner present 1638½ sup.feet @ 10/.f. f.p/o = 163.12.9 — labor @ 2.8.0 f.p/o = 40.15.2.
6	Sankoo — (Valuation 150.0.0)	9 Rooms average 12½' by 7'. 3 kucha roofs, 6 tiled, walls of Mud. 1 kucha pukka well 3 feet diameter	Owner present 787½ Sup.feet @ 6/.f. f.p/o with a well @ 5/.f. = 39.7.6 labor @ 2/8/.f. = 19.10.10.
7	Boodhoo — (Valuation 500.0.0)	16 Rooms average 11½' by 7'. 9 roofs of thatch and the rest of tiles. on mud walls. in tolerable order about 9' high	Owner present 1624 Sup.feet @ 7/.f. f.p/o = 113.10.10 labor @ 2/8/.f. = 36.8.7.
8	Goolall — (Valuation 175.0.0)	10 Rooms average 19'x9'. 6 kucha roofs, rest of tiles, mud walls in good order	Owner present 1530 Sup.feet @ 7/.f. f.p/o = 107.1.7. labor @ 2/8/.f. = 38.1.0.
9	Jemadar — (Valuation 900.0.0)	16 Rooms average 13½'x7'. 3½ kucha roofs, and 12½ tiles walls of mud	Owner present 4991 Sup.feet @ 6/.f. f.p/o = 299.7.3 labor @ 2/8/.f. = 99.14.9.
10	Sadoo — (Valuation 227.0.0)	7 Rooms about 12'x6½' Six roofs kucha, 1 tiled. 2 Rooms are 2 stories high. on mud walls.	Owner not present. 637 Sup.feet @ 1/8 f.p/o = 47.0.0 and a well and upper story at back 13.6.0 labor @ 2/8/.f. = 15.14.0.
11	Dunkee — (Valuation 2,000.0.0)	17 Rooms average 15½'x6½'. 1 roof tiled and rest mud, on mud walls.	Owner present 1713 Sup.feet @ 12/.f. f.p/o = 205.0.0 labor @ 3/.f.p/o = 51.4.0.
12	Munsa Ram — (Valuation 300.0.0)	9 Rooms about 16'x7'. Roofs all kucha on mud walls.	1003 Sup.feet @ 7/.f. f.p/o = 70.8.0 labor @ 2/8/.f. = 25.0.0.
13	Bheeka — (Valuation 110.0.0)	3 Rooms about 12½'x6' roofs kucha. One fallen in. walls mud	226 Sup.feet @ 6/.f. f.p/o = 13.3.0 labor @ 2/.f. = 4/8/.f. a small portion of the house only taken
14	Nunka — (Valuation 50.0.0)	3 Rooms average 7'x5' Roofs mud on mud walls.	105 Sup.feet @ 7/.f. per/o = 7.5.7. labor @ 2/8/.f. = 2.8.0 very small portion only taken.
15	Sewa — (Valuation 180.0.0)	2 Rooms about 12'x6½'. Roofs mud, thatch - chopper at. lacked walls of mud old.	226 Sup.feet @ 8/.f.p/o f.p/o = 18.0.0. labor @ 2/8/.f. = 5.10.0 a small part of the house only taken.
16	Purdothom and Davedeen — (Valuation 800.0.0)	15 Rooms average 15½'x7'. from roofs kucha and 9 tiled walls of Mud, not in good order.	1627½ Sup.feet @ 6/8/.f. per/o = 105.12.0 labor @ 2/.f. = 32.8.9.
17	Goolah — (Valuation 50.0.0)	7 Rooms about 16½'x8½'. 4 roofs kucha, 3 tiled, walls of Mud, not in good order.	901½ Sup.feet @ 2/8/.f. f.p/o = 58.15.0 labor @ 2/.f. = 19.10.0.
18	Doraswer — (Valuation 400.0.0)	13 Rooms about 12½'x6½'. 5 roofs kucha and rest tiled. walls mud, and not in good order	1056 Sup.feet @ 6/.f. f.p/o = 70.16.0 labor @ 2/8/.f. = 26.6.0
19	Authoo — (Valuation 105.0.0)	3 Rooms about 12'x7½'	326 Sup.feet @ 6/8 f.p/o = 21.3.0 labor @ 2/8/.f. = 8.2.0
20	Byjoo — (Valuation 65.0.0)	5 Rooms about 11'x8' Roofs kucha and walls mud.	440 sup.feet @ 6/.f. f.p/o = 26.6.8 labor @ 2/8/.f. = 11.0.1
21	Ruhan — (Valuation 66.0.0)	4 Rooms average 22'x6½'. 1 Roof kucha 3 tiles. walls mud.	570 Sup.feet @ 6/.f. f.p/o = 28.9.7. labor @ 1/8/.f. = 8.8.9

22	Kashee Dass Valuation 0 . 0 . 0	1 of Rooms about 10'x7'- 1 Roofs kucha and 2 tiled walls of mud. foundations of one wall kucha pukka in tolerable order	1190 Sup[f] feet @ 9/-/- ₹ % = 10 7 1 7 labor @ 3/-/- = 35 11 0 Owner not present.	
23	Pertab Valuation 135 . 0 . 0	5 Rooms average 11½ x 6½. 3 roofs kucha and 2 tiled, walls of mud not in good order	373 Sup[f] feet @ 5/-/- ₹ % = 18 10 6 labor @ 1/8/- = 6 8 0	
24	Chinta Valuation 150 . 0 . 0	4 Rooms about 13'x8'- 2 rooms of 2 stories. 1 roof kucha and three tiled. walls of mud.	520 Sup[f] feet @ 5/-/- ₹ % = 26 1 0 labor @ 2/-/- = 10 6 4	
25	Rambux Valuation 10 . 0 . 0	1 Room 18'x7½' roof tiled. walls mud.	129½ Sup[f] feet @ 5/-/- ₹ % = 6 13 0 labor @ 1/3/- = 2 0 0 Owner absent	
26	Dullee Valuation 60 . 0 . 0	3 rooms 10 ¾ x 6½ - 1 roof mud. and 2 of tiles. walls mud. not in good order	209 Sup[f] feet @ 5/-/- ₹ % = 10 7 2 labor @ 1/8/- = 3 2 0	
27	Govind Valuation 60 . 0 . 0	3 rooms 10½ x 5'- 2 roofs kucha and 1 tiled. also a tiled shed, walls mud	630 Sup[f] feet @ 5/-/- ₹ % = 31 8 0 labor @ 2/-/- = 12 9 7	
28	Doorjun Valuation 60 . 0 . 0	3 rooms 13'x7'- 1 Room 2 stories 4 roofs tiled, and 1 mud. dilapedated, walls mud	1,156 Sup[f] feet @ 5/-/- ₹ % = 22 12 0 labor @ 2/-/- = 9 1 7	
29	Khoodabux Valuation 80 . 0 . 0	3 rooms 14'x7½'. 2 mud roofs and 1 tiled, mud walls in bad order	816 Sup[f] feet @ 5/-/- ₹ % = 15 12 0 labor @ 1/8/- = 4/12/-	
30	Deena Valuation 60 . 0 . 0	2 rooms 21½ x 6½. 1 kucha and 1 tiled roof. mud walls not in good order	279½ Sup[f] feet @ 5/-/- ₹ % = 16 10 9 labor @ 2/-/- = 5 9 0 a portion of house.	
31	Sebsook Valuation 50 . 0 . 0	2 rooms 10½ x 5' roofs kucha, walls of mud	126 Sup[f] feet @ 1/-/- ₹ % = 0/13/- labor @ 2/8 = portion of house	
32	Narain Dass Valuation 112 . 0 . 0	3 rooms 12'x7' in bad order	Owner not present. 280 Sup[f] feet @ 5/-/- = 16 2 0 - In ruins portion rear occupied. sheds	

Attending the Committee
(Signed) John Eliot Lieutt
Supt. & Asst. to D[y] Q. Genl
(Signed) Geo. Sim Lieutenant
Asst to Co. Engr 7th Division
(Signed) Nasir Ally

(Signed) G. W. Hutchinson Lieutt.
Co. Engineer 6th Div. Goruckpore Canal

(Signed) T. Ashburnham Brigadier
Commanding the Station

(Signed) G. Crompe Major — President
(Signed) A. Riddell Captain
(Signed) W. Wildon Captain
(Signed) R. Wroughton Lieut[t] — Members

Perform travelling and purpose of which Come in the Line Required for the Ganges Canal through the Sudder Bazar and Fort
Merits.

Remarks. Cawnpoor 4th March 1851.

2nd Section

President Major C. Troup

Captain G. R. Siddons, Lieutenant R. Wroughton } Members { Captain T. Riddell, Syud Nasir Alli Khan Deputy Magistrate.

2a

No.	Names of and Valuation by Owners	Description	Remarks by the Committee
1	Unmeerdeng — Valuation 3000.0.0	43 Rooms. average 10.3" × 8½ - 33 Rooms of kucha roofs, the rest of tile, on walls 11½' high 1 Wall of 13 Rooms and 2 of 2 - of kucha pukka Masonry and of the rest of Mud in fair order. 1 Buttress on the side of the Bank of kucha pukka masonry 5'×9'×5½'.	1105 Sup.feet @ 12/. ₱ ℅ = 132.10.0. 2550 @ 7/. = 178.8.0. kucha pukka Revetment 55'×9'×5' @ 6/. = 14.8.0. Total 459.10.0. labor @ 2/℅ = 91.5.0. part only required.
2	Dhunee — Valuation 150.0.0	8 Rooms average 15'×6½' 5 Roofs of kucha, the rest of tile on mud walls 9¼' high in fair order, 1 shed with tile roof.	750 Sup.feet @ 5/. ₱ ℅ = 39/. labor @ 1/℅ = 11.12.0.
3	Oodyt — Valuation 75.0.0	5 Rooms average 15'×7'- 3 Roofs of kucha (in ruins) and the rest tiles on mud walls 10½' high in bad order.	525 Sup.feet @ 4/℅ ₱ ℅ - 21/. labor @ 1/℅ = 7.12.0 in bad order.
4	Doorjun — Valuation 50.0.0	4 Rooms average 12'×7½'- 2 kucha roofs the rest tiled on mud walls about 7' high in bad order, 2 small sheds. 1 tiled the other thatched.	360 Sup.feet @ 3/. ₱ ℅ - 10/. labor @ 1/℅ = 5/4. in bad order.
5	Moorga — Valuation 90.0.0	4 Rooms average 7¼'×4½'- 2 kucha Roofs and 2 tiled the latter one of 2 stories - walls mud about 12 feet high in fair order.	130 Sup.feet @ 5/. ₱ ℅ = 6/12. labor @ 1/℅ = 1/12. in very bad order.
6	Durma — Valuation 75.0.0	5 Rooms average 13½'×7'- 2 kucha roofs the other tiled on mud walls about 8' high in bad order.	472 Sup.feet @ 3/℅ ₱ ℅ = 15/8. labor @ 1/℅ - 3/.
7	Puntah — Valuation 300.0.0	9 Rooms average 16'×7½'- 4 kucha roofs the rest tiled on mud walls about 9' high in fair order.	1080 Sup.feet @ 7/. ₱ ℅ = 75/0. labor @ 2/8 = 27/. in good order.
8	Bullooaha — Valuation 67.0.0	2 Rooms average 21'×8½'. One kucha the other tiled roof mud walls about 10' high in fair order.	346 Sup.feet @ 4/. ₱ ℅ - 13/4. labor @ 1/℅ = 5/4.
9	Pershad — Valuation 15.0.0	1 Room 9½'×6¾' with tiled roof mud walls 6½' high in bad order.	62 Sup.feet @ 4/. ₱ ℅ = 2/3. labor @ 1/℅ = 0/14.
10	Doola — Valuation 80.0.0	6 Rooms, average 9½'×17½' One kucha roof the others tiled on mud walls about 8' high in bad order.	971 Sup.feet @ 4/. ₱ ℅ = 38/8. labor @ 1/8. = 14/8.
11	Shadee — Valuation 132.0.0	4 Rooms average 10¼'×5¾'- 1 Roof kucha the others tiled mud walls about 7' high in fair order - 2 rooms with 2 stories.	235 Sup.feet @ 6/. ₱ ℅ = 15/4. labor @ 2/. = 4/9.
12	Munniram — Valuation 80.0.0	3 Rooms average 6⅔'×5⅔'- 2 of 2 stories with tiled roofs the other of kucha, mud walls about 13½' high in fair order.	150 Sup.feet @ 7/. ₱ ℅ = 10/8. labor @ 5/. = 7/8.
13	Sheda — Valuation 100.0.0	4 Rooms average 10'×5½'- kucha roofs, walls of mud about 10 feet high in	227 Sup.feet @ 6/8. ₱ ℅ - 11/12. labor @ 2/. = 4/8.

14	Buddoollah Valuation 110 „ 0 „ 0	6 Rooms average 12½ × 6¾ - 3 kucha roofs 2 tiled and 1 thatched mud walls about 9¾ high in bad order.	444 Sup^d feet @ 5/„ ℔ ℅ = 22½ „ labor @ 1/8 „ = 6/9 „ In very bad order
15	Woora Valuation 300 „ 0 „ 0	5 Rooms average 12 × 6' - 4 kucha and 1 tiled Roof mud walls about 8' high in bad order.	360 Sup^d feet @ 5/„ ℔ ℅ = 18/„ labor @ 1/8 „ = 5/6 „
16	Bhuckha Valuation 32 „ 0 „ 0	2 Rooms average 16¼ × 16½ Kucha roofs on mud walls about 8½ high in bad order 1 Roof nearly in ruins.	214 Sup^d feet @ 4/8 „ ℔ ℅ = 9/8 „ labor @ 1/8 „ = 3/4 „
17	Dhunoon Valuation 20 „ 0 „ 0	5 Rooms 10½ × 6'. 3 kucha and 2 tiled Roofs mud walls 7' high in very bad order.	315 Sup^d feet @ 4/„ ℔ ℅ = 12/8 „ labor @ 1/8 „ = 4/12 „
18	Munsa Valuation 98 „ 0 „ 0	3 Rooms average 16½ × 6⅔ - 2 kucha and 3 Tiled Roofs Mud walls about 7' high in bad order.	300 Sup^d feet @ 7/„ ℔ ℅ = 21/„ labor @ 2/- = 6/-
19	Madar and Dhore Valuation 12 „ 0 „ 0	1 Room 8½ × 7¼' tiled roof walls mud, about 6' high, in very bad order - 1 tiled shed.	61 Sup^d feet @ 4/„ ℔ ℅ = 2/8 „ labor @ 2/„ = 1/3 „
20	Bullowa Valuation 30 „ 0 „ 0	1 Room 23' × 9¾ tiled Roof on mud walls 7½' high in bad order.	224 Sup^d feet @ 4/„ ℔ ℅ = 8/15 „ labor @ 1/8 „ = 3/5 „
21	Bidumber Valuation 40 „ 0 „ 0	1 Room 15¾ × 6⅓ ____ Do: ____ Do: ____ Do: ____	99 Sup^d feet @ 5/„ ℔ ℅ = 4/15 „ labor @ 1/8 = 1/8 „ a portion only taken
22	Ramzan Valuation 45 „ 0 „ 0	2 Rooms 13¼ × 8' tile roofs, mud walls 10 feet high in bad order.	212 Sup^d feet @ 5/„ ℔ ℅ = 10/8 „ labor @ 1/8 „ = 3/12 „ In bad order
23	Poluz Valuation 0 „ 0 „ 0	Part of a side wall of the house 6' in height. mud, in fair order.	
24	Sadharee Valuation 200 „ 0 „ 0	6 Rooms average 12⅓ × 7⅓ tile roofs mud walls 7½ high. in fair order.	540 Sup^d feet @ 6/„ ℔ ℅ = 32/„ labor @ 2/„ = 10/12 „
25	Nugnoo Valuation 80 „ 0 „ 0	6 Rooms 15½ × 7⅓ tile roofs mud walls in fair order 7½ high.	657 Sup^d feet @ 4/„ ℔ ℅ = 26/„ labor @ 1/8 „ = 9/12 „ in bad order
26	Ghedah Valuation 25 „ 0 „ 0	3 Rooms 19¾ × 6' Kucha Roofs mud walls 8½ feet high in bad order.	355 Sup^d feet @ 5/„ ℔ ℅ = 17/12 „ labor @ 1/8 „ = 5/5 „

			1100 Sub Feet @ 9/1/- ₰ ₰/o = 10/1.1	labor @ 3/1/- = 35/11/2 Amt. evalisent.
22	27 Ramzan Fard's	3 Rooms 17½'x8' tile roofs on mud walls 10 feet high	400 Sup Feet @ 4/1/- ₰ ₰/o = 16/2/-	labor @ 1/8/- = 6/1/-
	Valuation 50-0-0	in bad order		
23	28 Chunnee	9 Rooms 12'x6½' 8 of kucha the rest tile roofs. on 2 stories	675 Sup Feet @ 5/1/- ₰ ₰/o = 33/12/-	labor @ 2/1/- = 13/5/-
24	Valuation 150-0-0	Rooms Mud walls. 9½' high in bad order		
	29 Gursamding	2 Rooms 22'x10'. tile roofs. Mud walls 11½' high in bad	440 Sup Feet @ 7/1/- ₰ ₰/o = 30/12/-	labor @ 2/1/- = 8/13/-
25	Valuation 105-0-0	order, 1 rooms 2 stories.		
	30 Esuric	5 Rooms 15½ x 5½ one of 2 stories mud walls 9½' high in bad	426 Sup Feet @ 4/1/- ₰ ₰/o = 17/1/-	labor @ 1/8/- = 6/3/-
26	Valuation 95-0-0	order tile Roofs.		
	31 Sahtawan	6 Rooms 13⅔'x6'. 2 kucha the rest tiled roofs mud walls 7' high	492 Sup Feet @ 4/1/- ₰ ₰/o = 19/10/-	labor @ 1/8/- = 7/1/-
27	Valuation 100-0-0	one with a kucha pukka foundation 19½'x6'.		
	32 Sabhar	4 Rooms 13½'x7½'. 1 kucha the rest tiled roofs. 1 Room with 2	405 Sup Feet @ 5/1/- ₰ ₰/o = 20/1/-	labor @ 1/0/- 6/1/-
28	Valuation 90-0-0	stories mud walls 6½' high in bad order		
	33 Chand	5 Rooms 19¼'x6¼'. 1 kucha the rest tiled roofs. 1 Room 2 stories	601 Sup Feet @ 5/1/- ₰ ₰/o = 30 x wall @ 10/- = 40/1/-	
	Valuation 300-0-0	Mud walls 10' high in fair order.	labor @ 1/0/- = 9/6/-	
	34 Cheda	7 Rooms 11¼'x6½'. One kucha the rest tile roofs, mud	633 Sup Feet @ 5/1/- ₰ ₰/o = 31/3/-	labor @ 1/0/- = 9/9/-
	Valuation 100-0-0	walls. 6' high in bad order.		
	35 Goordial	2 Rooms 15¾'x8¼' tile roofs Mud walls. 6' high in bad	260 Sup Feet @ 3/1/- ₰ ₰/o = 7/12/-	labor @ 1/8/-
	Valuation 40/0/0	order.	= 3/14/-	
	36 Fakeeraz	4 Rooms 14¼'x6'. 2 kucha and 2 tile roofs mud walls	312 Sup Feet @ 7/- ₰ ₰/o = 23/13/-	labor
	Valuation 64/0/-	9 feet high in fair order. North west walls plinth and	@ 2/1/- = 6/13/-	
		foundations 3 kucha pukka masonry 6 feet deep		
		and kutcha floor		

	Valuation 31 " 0 " 0	fair order	24 Sup. feet @ 4/ " pp 96 = 2/4 " Labor @ 1/0 " = 0/13 "
38	Obeda	3 Rooms 13' x 6 3/4 1 Kucha the rest tiled roofs mud walls	263 Sup. feet @ 4/ " pp 96 = 10/8 " Labor @ 1/3 " = 3/4 "
	Valuation 36 " 0 " 0	7 1/2 feet high in bad order.	
39	Soobba	2 Rooms 13 1/2 x 6 1/2 1 Kucha the others tile roofs mud walls 7'	172 Sup. feet @ 3/ " pp 96 = 6/2 " Labor @ 1/ " = 1/11 "
	Valuation 15 " 1 "	high in bad order.	

/Signed/ C. W. Hutchinson Lieut.
Executive Engineer 6th Div. Ganges Canals

Attending the Committee

/Signed/ John Eliot Lieut.
Temp. Asst. 6th Div. Ganges Canal

/Signed/ Geo: Sim Lieutenant
Offg Ex: Engineer 1st Division

/Signed/ C. Crompton Majr. President

/Signed/ G. R. Seddons Captain
/Signed/ J. Riddell Captain
/Signed/ R Broughton I. A. C. G.
/Signed/ Nasir Alli.

Members

/Signed/ P. Ashburnham Brigadier
Commanding the Station.

the Suddur Bazar and Cantonment — Cawnpore 8th March 1854

3d Section

President Major C. Fraser

Members: Captain G. R. Siddons, Lieutenant R. Broughton, Captain P. Riddell, Syud Nasir Alli Khan Deputy Magistrate

3a

No:	Names of and Valuation by Owners	Description	Remarks by the Committee.
1	Ghundun Sing — Valuation 3,200.0.0	4½ Rooms average 15×6½ ten of tile and the rest of Kucha Roof but three which are of pukka, four rooms are 2 Story high about 166 feet length of wall 11½ feet high and formation is of Kucha Pukka Masonry and the rest of mud. 2 tile sheds average 21×8½ on Mud pillars, in fair order.	The whole to be taken = 1000.0.0 Labr 20/1.
2	Ramlall and Poorun — Valuation 100.0.0	3 rooms Average 8×6½ of Kucha Roof. walls mud. about 9 feet high in bad order.	150 Sup.t feet @ 6/1.0 ₱ ⅞ = 9/1.0 Labr @ 2/1.0 = 3/1.0 Only a portion taken.
3 (KK, 249; V. iii.)	Ghand Khan — Valuation 30.0.0	2 rooms Average 11¾×6½ of Kucha Roof. Walls Do: Do:	152 Sup.t feet @ 5/1.0 ₱ ⅞ = 7/9.0 Labr @ 1/0.0 = 2/1.0 a small portion taken
4	Gooraj — Valuation 1500.0.0	4 rooms average 13×6½ 3 of Kucha Roof and the fourth of pukka and two story, walls of One room of pukka, Kucha Masonry and the rest of mud in fair order	120.0.0 This Valuation has been assumed on account of superior materials and workmanship and although part only is taken it will destroy a greater part of the property not taken by Canal Officers.
5	Simboo — Valuation 1000.0.0	6 rooms average 9½×6½ three of Kucha Roof and three of pukka two of the lastare 2 Story, walls about 12 feet high of kucha Pukka Masonry in fair order	180.0.0. Valuation adjudged by Committee.
6	Heera Lall — Valuation 210.0.0	2 rooms average 10½×10½ of Kucha Roof. Walls of Mud, about 13 feet high in fair order.	210 Sup.t feet @ 12/1.0 ₱ ⅞ = 25/3/1.0 Labr = 5/1.0 only portion taken.
7	Dullee — Valuation 225.0.0	2 rooms 11½×6½ of tile roof 2 Story walls Do Do	A portion only to be taken 234 Sup.t feet @ 8/1.0 ₱ ⅞ = 28/13/1.0 Labr @ 2/8/1.0 = 7/1.0/1.0 (Measd 5 Oct)
8	Khialee — Valuation 325.0.0	5 rooms average 9×5½ - 3 of Kucha roof and 2 of tile 2 Story high walls of Mud about 12 feet high in fair order	Front portion only taken @ 8/1.0 ₱ ⅞ = 22/10/1.0 Labr 7/1.0 owner not present.
9	Gungapurshad — Valuation 30.0.0	1 Room 17½×8½ of tile roof. Walls Do in bad order.	A portion only taken. 152 Sup.t feet @ 1/8 ₱ ⅞ 4/7.0 Labr @ 1/8/1.0 = 2/1.0/1.0.

3b

10	Jewahir Lall — Valuation 100.0.0	3 rooms average 11½×6' of Kucha Roof one 2 Story high. Walls of mud about 11 feet high in bad order	420 Sup.t feet @ 7/1.0 ₱ ⅞ = 29/9/1.0 Labr @ 2/1.0 = 8/7/1.0
11	Choonnee — Valuation 175.0.0	4 rooms average 11½×6' three of Kucha roof and one of tile, 2 Story high, walls Do Do Do	420 Sup.t feet @ 7/1.0 ₱ ⅞ 29/6/1.0 Labr at 2/1.0 = 8/7/1.0
12	Bukhtawur — Valuation 200.0.0	4 rooms Average 6'×4' - 3 of Kucha roof and one tile. 2 Story high walls Do Do Do	144 Sup.t feet @ 10/1.0 ₱ ⅞ = 11/7/1.0 Labr @ 2/8/1.0 = 3/7/1.0
13	Lukhuna — Valuation 20.0.0	3 rooms average 8'×5½ of kucha Roof, walls Do Do Do	135 Sup.t feet @ 5/1.0 ₱ ⅞ = 6/12/1.0 Labr @ 1/8/1.0 = 2/1/1.0
14	Kain Khund — Valuation 16.0.0	1 room 15½×7' of tile roof, walls Do Do Do	116 Sup.t feet @ 5/1.0 ₱ ⅞ = 5/12/1.0 Labr @ 1/0/1.0 = 1/12/1.0
15	Mohunlall — Valuation 250.0.0	3 rooms average 11×5½ of kucha roof, walls Do Do Do	A portion only taken. 176 Sup.t feet @ 6/1.0 ₱ ⅞ = 10/9/1.0 Labr @ 2/1.0 = 3/8/1.0.
16	Ramparsaud — Valuation 60.0.0	1 room or hall shed 19½×5½ wall of mud 9½ feet high in bad order.	A small portion taken. 105 Sup.t feet @ 2/1.0 ₱ ⅞ = 5/4/1.0 Labr @ 1/0/1.0 = 1/0/1.0
17	Muddanund — Valuation 375.0.0	2 Rooms average 10'×6' of kucha roof. 2 Story. walls Do 15 feet high Do Do	A small portion taken - 240 Sup.t feet @ 8/1.0 ₱ ⅞ = 19/4/1.0 Labr @ 2/8/1.0 = 6/1.0/1.0
18	Ramparsaud — Valuation 150.0.0	4 rooms average 10½×5½ one of kucha and the rest of tile roof walls Do Do	A portion only taken 210 Sup.t feet @ 6/1.0 ₱ ⅞ = 12/9/1.0 Labr @ 2/1.0/1.0 = 4/3/1.0.
19	Ondunee — Valuation 200.0.0	4 rooms average 13½×5½ of kucha roof walls Do Do Do	1 632 Sup.t feet @ 9/1.0 ₱ ⅞ = 40/14/1.0 Labr = 9/1.0/1.0.
20	Khuloonee — Valuation 1225.0.0	7 rooms average 17×7½ four of tile one of which is 2 Story high roof, and the rest of kucha walls of 2 rooms of kucha pukka masonry and of the rest of mud. also formation of pukka kucha masonry about 11 feet high in fair order.	Merely compound and roun. values - Tiles - 527 Superficial feet @ 4/1.0/1.0 per ⅞ = 21/1.0/1.0 Labr @ 1/8/1.0 = 7/11/1.0.

21	Ramburs Valuation—100.0.0—	6 rooms average 17½ × 8— three of tile roof and the rest of kucha walls of 3 rooms of kucha pukka masonry and the rest of mud in fair order about 8' high	828 Sup.feet @ 11/.1. ₱ %. 91.1. labor @ 3/9 ₱ %. 26/15/.	
22	Soobarao Yernamel Ramier Walls—Valuation—200.0.0—	1 room for his tombs 9½ × 9½ of Pukka roof, wall of Pukka kucha masonry pukka plastered about 11½ feet high in good order three other tombs in bad order	a tomb ₱ac. 100/.	3 c
23	Kullooa Mul Valuation—0.0.0—	6 rooms average 13⅓ × 8½ two of kucha and the rest of tile roof. walls of mud about 7 feet high. the 2 rooms of kucha roof in good order and the others in bad	698 Sup.feet @ 3/.1. ₱ %. 32.15/. labor @ 2/.1. = 13/15/.	
24	Munneraw Valuation—0.0.0—	2 rooms average 8½ × 6' two of kucha roof one of tile and one of grass, walls of mud 7 feet high in bad order.	192 Sup.ft. @ 1.1. ₱ %. 7/12/. labor @ 1/8/. = 2/12/.	
25	Murdarbux Valuation—50.0.0—	2 rooms average 11 × 7' of tile roof walls of mud 7½ feet high in bad order.	196 Sup.feet @ 1/.1. ₱ %. 7/13/. labor @ 1/5/. = 2/14/.	
26	Shamut Khan Valuation—36.0.0—	5 rooms average 12 × 6½ One of grass roof and the rest of kucha walls— Do: —Do:	390 Sup.feet @ 2/.1. ₱ %. 7/13/. labor @ 1/.1. = 3/13/.	
27	Blakeling Valuation—50.0.0—	3 rooms average 16⅔ × 6½ two of kucha and one of tile Roof walls— tile— Do	304 Sup.feet @ 4/.1. ₱ %. 12/3/. labor @ 1/8/. = 2/9/.	
28	Buggumanth Valuation—300.0.0—	9 rooms average 13⅓ × 6½ six of tile roof and 2 stone high and the rest of kucha roof, walls of mud about 11 feet high in fair order	1080 Sup.feet @ 30/.1. ₱ %. 324/. labor @ 6/.1. = 54/.	
29	Sukkum Valuation—0.0.0—	10 rooms average 9½ × 6'. three of tile roof 2 stone high, and the rest of kucha, walls of mud—Do: —Do:	570 Sup.feet @ 12/.1. ₱ %. 68/. labor @ 4/.1. = 22/12/.	
30	Sujjoo Valuation—2.0.0—	2 rooms average 13½ × 6½ One of kucha roof and the other of tile. walls of mud, in bad order. height of walls about 9' high.	Do very bad order = 4/.1.	
31	Lacoo Valuation—275.0.0—	5 Rooms average 15 × 6' two of kucha roof and two of tile, one of which is 2 stone high, walls of mud—Do —Do	630 Sup.feet @ 5/.1. ₱ %. 60/. labor @ 3/.1. = 18/15/.	
32	Bheda—Valuation—46.0.0—	Room 15½ × 6' of tile roof 2 stone, walls of mud 12 feet high in fair order	186 Sup.feet @ 7/.1. ₱ %. = 13/. labor @ 2/.1. = 3/12/.	

33	Chinnaw Valuation—150.0.0—	6 rooms average 11½ × 8½ two of tile roof and the rest of kucha walls of 3 rooms of kucha pukka masonry and the rest of mud 10 feet high in bad order one tile shed 11 × 5½	528 Sup.feet @ 6/.1. ₱ %. 22/10/. labor @ 3/.1. = 11/.	

33	Chulnam Valuation 150„0„0	6 rooms average 11½×6½ two of tile roof and the rest of kucha, walls of mud 10 feet high in bad order. One tile shed 11×5¾	484 Sup.Feet @ 6/„/„ ₱ %= 22/12/„ labor @ 2/„/„ = 9/1/„
34	Bhageerut Valuation 335.0„0	8 rooms average 10'×5½' four of tile and one of Grass 2 Story, the rest of kucha roof, walls of mud in bad order, high, about 10 feet	660 Sup.Feet @ 10/„/„ ₱ %= 66/„/„ labor @ 2/„/„ = 13/3/„
35	Lodhee Valuation 276„0„0	4 rooms average 10¼'×7¼' two of tile roof 2 story high, and the rest of kucha roof, walls of mud 10 feet high in good order	445 Sup.Feet @ 16/„/„ ₱ %= 71/„/„ labor @ 3/„/„ = 13/5/„
36	Gaiadeen Valuation 800„0„0	9 rooms average 7'×6' of kucha roof, walls of mud 11 feet high in good order	378 Sup.Feet @ 30/„/„ ₱ %= 113/6/„ labor @ 4/„/„ = 13/5/„ wood work much
37	Goobroy Valuation 200„0„0	8 rooms average 9½'×6' of tile roof one 2 story tile, walls 9½ feet high in good order	513 Sup.Feet @ 6/„/„ ₱ %= 30/12/„ labor @ 1/8/„ = 7/9/„
38	Ponsand Valuation 380„0„0	18 rooms average 13¼'×8' four of kucha roof and the rest of tile walls of mud 7 feet high in bad order, three tile sheds 26×6⅔.	1908 Sup.Feet @ 6/„/„ ₱ %= 114/8/„ labor @ 2/„/„ = 38/2/„
39	Rooelee Valuation 250„0„0	6 rooms average 13'×⅔' two tile roof and the rest of kucha, walls —Do— —Do— in bad order, one 2 Story	150 Sup.Feet @ 6/„/„ ₱ %= 36/„/„ labor @ 2/„/„ = 9/„/„
40	Munherdoss Valuation 400„0„0	3 rooms average 8⅔'×6⅔' one of kucha roof and the rest of tile walls of one room of pukka kucha Masonry the rest of mud 6' high also foundations of kukka kucha masonry in fair order.	150 Sup.Feet @ 20/„/„ ₱ %= 30/„/„ labor @ 2/8/„ = 3/12/„ a very small portion only taken.
41	Silokee Valuation 160„0„0	9 rooms average 13½'×4½' four of tile roof 1 of which is 2 story and the rest of kucha roof walls of mud 8 feet high in bad order	668 Sup.Feet @ 8/„/„ ₱ %= 53/6/„ labor @ 2/„/„ = 13/4/„
42	Lavo Valuation 200„0„0	5 rooms average 19¼'×6⅓' of kucha roof, also 2 Grass sheds supported on pillars of mud, walls of mud 8¼' high in bad order	670 Sup.Feet @ 6/„/„ ₱ %= 40/4/„ labor @ 1/8/„ = 10/„/„
43	Goordeew Valuation 350„0„0	10 rooms average 16½'by 5¾' four of tile roof and the rest of kucha walls of mud —Do— —Do—	934 Sup.Feet @ 8/„/„ ₱ %= 75/12/„ labor @ 2/„/„ = 18/8/„

44	Byjnauth _____ Valuation 1000„0„0	11 rooms average 12½ × 5. two of tile, one of pukka roof, 2 story high and the rest of kucha roof walls 285 feet long and about 15 feet high of kucha pukka masonry as also the foundations, the rest walls of mud in good order, part of the Court yard 24½ × 8 pukka plastered.	For all 1000„„ labor 200„„
45	Koolaba _____ Valuation 150„0„0	6 rooms average 10½ × 8', one of kucha roof and the rest of tile of which 3 are 2 story high, walls of mud about 8 feet high in very bad order	756 Sup Feet @ 6„„ ₱ ₰ = 45„„ labor @ 1/8„ = 11/6„
46	Khowaneedeen _____ Valuation 100„0„0	11 rooms average 18 × 6½, 2 of tile roof and the rest of kucha walls of mud 8½ feet high foundations of a wall 51 feet long of Pukka kucha masonry in fair order.	1287 Sup Feet @ 8„„ ₱ ₰ = 103„„ labor @ 2„„ = 25/12„
47	Godab Khan Kotwal _____ Valuation 800„0„0	8 rooms average 16½ × 7½' three of kucha roof and the rest of tile, walls of mud 11½ feet high in bad order	942 Sup Feet @ 6„„ ₱ ₰ = 56/8„ labor @ 2„„ = 13/12„
48	Dhooma _____ Valuation 600„0„0	9 rooms average 9³ × 7 six of tile roof, two which are 2 story and the rest kucha, foundations of kucha pukka masonry, walls of mud about 10 feet high in bad order	748 Sup Feet @ 7„„ ₱ ₰ = 52/4„ labor @ 2„„ = 15„„
49	Buldeo _____ Valuation 500„0„0	5 rooms average 15 × 7 two of tile roof one of which is 2 story and the rest of kucha, walls of mud 11 feet high in bad order.	630 Sup Feet @ 7„„ ₱ ₰ = 44/2„ labor @ 2„„ = 12/8„
50	Roshun Lall _____ Valuation 650„0„0	7 rooms average 11 × 5' of kucha roof, half of which is 2 story, walls about 56 feet long and foundations of Pukka kucha masonry the rest of mud in fair order	—
51	Nerdoss _____ Valuation 3500„0„0	19 rooms average 10½ × 6½ seven of tile roof and 2 of Pukka 2 story, and the rest of kucha, walls about 360 feet long 16½ feet high of pukka kucha masonry and the rest of kucha in fair order.	For the whole 1200„„ Labor 250„„
52	Ramall _____ Valuation 3000„0„0	6 rooms average 12' × 6⅓' one tile roof one Pukka and the rest kucha, walls of 4 rooms and front one of Pukka kucha masonry, as	532 Sup Feet @ 60„„ ₱ ₰ = 319„„ labor = 82„„

	Valuation	24½ feet long and 6¾ feet high	only in an open plot = 5/"/-
54	Chatooree	3 rooms average 21¾ × 8½ One of tile and the rest of kucha	Value = 170/"/- Labor = 40/"/-
	Valuation 1050"0"0	roof, walls of 2 rooms of kucha Pukka masonry, and of the other of mud, and in bad order height about 12 feet, one grass shed 21¼ × 13¾.	
55	Ujoodeea punsaud	2 rooms average 16 × 7⅓ One of kucha roof and the other of the	240 Sup feet @ 3/"/- per %o = 7/4/"- Labor @ 1/8/"- = 3/6/"-
	Valuation 20"0"0	walls of mud 6 feet high in bad order.	
56	Persram	5 rooms average 9¾ × 6½ of kucha roof walls of kucha pukka	Value = 350/"/- Labor = 80/"/-
	Valuation 1000"0"0	Masonry in good order	
57	Doonkeeram	7 rooms average 11¼ × 8½ one of tile roof and the rest of kucha	Value = 600/"/- Labor = 80/"/-
	Valuation 1100"0"0	walls — Do — Do	
58	Werdoss	5 rooms average 21½ × 9½ of pukka roof, walls of kucha pukka	Value = 1000/"/- Labor = 200/"/-
	Valuation 800"0"0	masonry 13½ feet high one outer wall 57 feet long puk- ka plastered, in good order	
59	Moonjeeram	15 rooms average 14½ × 8 fourteen of pukka roof of tile	Value = 3000/"/- Labor = 1000/"/-
	Valuation 10,000"0"0	one 2 story high walls of pukka kucha masonry about 12 feet high in fair order, two tile sheds 27½ × 8½ one pukka shed 12⅓ × 6½.	
60	Buldeo & Bukhtawur	11 rooms average 13 × 8½ of kucha roof, 5 rooms 2 story	Value = 2000/"/- Labor = 680/"/-
	Valuation 10,000"0"0	walls of pukka kucha masonry about 15 feet high in good order	
61	Chubbadrig	5 rooms average 13 × 5½ One of kucha roof & the rest of tile. 2 of which are 2	500 Sup feet @ 10/"/- per %o = 30/"/- Labor @ 4/"/- = 20/"/-
	Valuation 138"0"0	story high, walls of mud about 9' high in fair order.	

2	62	Serwun Valuation 50„ 0„ 0	3 Rooms average $11\frac{2}{3}' \times 5\frac{2}{3}'$ One of tile and the rest of Kucha walls of mud about 9' high in bad order	180 Sup Feet @ 7/-/- P° = 10/12/- Labor @ 2„/-/- = 3/9/-
2	63	Bulder Valuation 300„ 0„ 0	5 Rooms average $11\frac{1}{2} \times 6\frac{1}{2}$ of Kucha Roof but one, which is of tile Roof and 2 Stone high walls of mud about $8\frac{1}{2}$ feet high in bad order	
2				

(Sd) G. W. Hutchinson Lieutt:
Ex: Engr 6th Divn Ganges Canal

Attending the Committee

(Sgd) John Eliot Lieutt
Temporary Asst Ganges Canal

(Sgd) Geo: Pine Lieutt.
Offg Ex: Engr 1st Divn

(Sgd) J. Ashburnham Brigadier
Commanding the Station.

(Sd) G. Thompse Major — President

(Sgd) G. R. Siddons Captain
(Sgd) J. Riddell Captain
(Sgd) R. Wroughton Lieutt
} Members

Bazar and Cantonment — Cawnpoor 18th March 1837

4th Section

President — Major C. Prouse

4a

Captain G.R. Siddons, Lieutenant R. Wroughton } Members { Captain P. Riddell, Syud Nasir Alli Deputy Magistrate

No	Names of and Valuation by Owners.	Description	Remarks by the Committee
1	Baneeram & Gungadeen (Absent)	2 rooms average 18'×8¾' one of tile and the other of kucha roof. walls of kucha Pukka masonry about 9 feet high in fair order	Owner not present. 311 Sup.feet @ 10/"/" p ⅟₀ = 31/2/" Labor @ 2/"/" = 7/12/"
2	Nungoo — Valuation 1200"0.0	14 rooms average 10½×7' of kucha roof. 6 of these are 2 story 3 of kucha Pukka masonry and the rest of mud about 9½ feet high in very bad order. also 2 tile sheds 11½×7⅓.	1470 Sup.feet @ 6/"/" p ⅟₀ = 73/8/" = Labor @ 2/"/" = 29/6/"
3	Monjee Ram (Absent)	4 rooms Average 15'×9½' two of Pukka roof. 2 story high and the rest of kucha, Walls kucha Pukka masonry 11¼ feet high in fair order, also one tile shed 23×7⅓	555 Sup.feet = 400/"/" Labor = 100/"/"
4	Thakoordoss — Valuation 500"0"0	7 Rooms Average 17¼×6½ of kucha roof, walls of Mud. 10½ feet high, in bad order.	739 Sup.feet @ 8/"/" p ⅟₀ = 61/3/" Labor @ 2/8/" = 18/7/6
5	Deena — Valuation 2000"0"0	8 rooms average 9⅓×6⅔ three of tile roof and the rest of pukka, walls of 3 rooms of pukka kucha masonry and the rest of mud 10¼ feet high in fair order, one tile shed 20½×7¼	Value = 250/"/" Labor = 80/"/"
6	Khemanund and Gunga-Bishun Valuation 4,000"0"0	4 rooms average 17½×7½ two of tile roof and two story and the rest of Pukka roof Walls of kucha pukka masonry 11¼ feet high in fair order, one tile shed 20½×7½.	Value = 500/"/" Labor = 130/"/"
7	Ramdial — Valuation 400"0"0	15 rooms average 16¼×6½ two of tile roofs 2 story high and the rest of pukka and kucha roofs, wall about 151 feet long and 10¼ feet high of kucha pukka masonry, the rest of mud in good order.	Value = 320/"/" Labor 100/"/"
8	Rimond Ram — Valuation 1,000"0"0	10 rooms average 16½×8½. Six of pukka roofs, 2 story high, walls of kucha Pukka masonry one side pukka plastered	Value = 2300/"/" Labor = 766/"/"

		walls of 4 rooms of mud, 10 feet high in very good order.	
9	Poo Hoo Valuation 2000,,0,,0	9 rooms average 10½ × 5½ - 7 roofs Kucha and 2 tiled. walls of Kucha Pukka Masonry 10¾ feet high in good order.	Value = 118/,,/- Labor = 17/13/,,
10	Rampersaud Valuation 600,,0,,0	17 rooms average 13¾ × 5½ of Kucha roofs. walls of one room of Kucha Pukka masonry and the rest of mud 9 feet high in bad order, one tile shed 10¾ × 7½ - two of Kucha roofs in ruins.	1238 Sup Feet @ 16/,,/- P C. 207/,,/- Labor @ 4/,/- = 49/8/,,.
11	Bholanauth Valuation 3,000,,0,,0	19 rooms average 9¾ × 6¾ one of tile and the rest of Kucha roof. walls of 5 rooms of Kucha pukka masonry and of the rest of mud 11 feet high in bad order. one tile shed 37 × 7¾.	1280 Sup Feet @ 25/,,/- P C. = 300/,,/- Labor @ 4/,/- = 80/,,/-.
12	Motee Valuation 413,,0,,0	11 rooms average 12 × 6½ Six of tile and the rest of Kucha roof. walls of mud. 9 feet high in bad order.	391 Sup Feet @ 7/,,/- P C. 62/11/,, Labor @ 2/,/- = 17/14/,,
13	Moona Lall Valuation 157,,0,,0	2 rooms average 16¾ × 5¼ roofs Kucha walls of mud 10' high in bad order.	175 Sup Feet @ 10/,,/- P C. = 17/8/,, Labor @ 2/3/,, = 4/5/,,
14	Ruddool Valuation 50,,0,,0	1 room 20¾ × 10' of tile roof. wall of mud 7 feet high in bad order.	207 Sup Feet @ 5/,,/- P C. = 10/,,/-. Labor @ 1/3/,, = 3/,,/-
15	Jungaram (absent) Valuation 800,,0,,0	6 rooms average 18½ × 7½ two of tile roof and 2 story high and the rest Kucha, walls mud 11 feet high in fair order. One tile shed 15½ × 6½.	832 Sup Feet @ 6/,,/- P C. = 49/15/,, Labor @ 2/,/- = 16/9/,,
16	Khemchund Valuation 800,,0,,0	8 rooms average 13 × 5½ - two rooms pukka. rest Kucha Wall about 62 feet long and 8⅔ feet high of Kucha pukka masonry rest of mud in fair order.	552,,0 Sup Feet @ 30/,,/- P C. = 166/2/,, Labor @ 4/,,/- = 22/4/,,

17	Bullee _____ Flee Valuation 2000.0.0	5 rooms 19 x 4¾ - two of pukka roofs, 2 story high and rest kucha, wall 35 feet long and 10 feet high of mud rest of kucha Pukka masonry in good order	Value = 350/.. labor = 116/..	
18	Thundeeram and Sokemun. Valuation 400.0.0	7 rooms average 10½ x 5½ two of tile roofs 2 story high. 2 of kucha pukka and rest kucha roofs, walls of mud 10 feet high in bad order.	504 Sup feet @ 20/.. ₱ c. = 101/.. labor @ 2/8 = 42/..	
19	Tonkee _____ Valuation 400.0.0	10 rooms average 18½ x 6 roofs kucha, walls mud about 10 feet high, in bad order.	1110 Sup feet @ 10/.. ₱ c. = 111/.. labor @ 2/8 = 27/12/..	
20	Nund Kishore _____ Valuation 200.0.0	4 rooms average 11½ x 6½ three roofs tiled, 2 story high and one kucha, walls mud in fair order	534 Sup feet @ 8/.. ₱ c. = 42/10/.. labor @ 2/8 = 13/3/6	
21	Khoosal _____ Valuation 800.0.0	4 rooms average 15½ x 5½ - roofs kucha - 3 two storied, walls mud 15 feet high in good order, walls of front room of kucha pukka masonry.	Value = 400/.. labor = 100/..	
22	Sumber _____ Valuation 150.0.0	3 room average 15⅔ x 6½ roofs kucha walls of mud 12 feet high in bad order.	301 Sup feet @ 5/.. ₱ c. = 15/4/.. Labor @ 1/8 = 4/8/..	
23	Rickhee _____ Valuation 150.0.0	1 Room 22¼ x 5¾ roof tiled, walls mud in very bad order	130 Sup feet @ 5/.. ₱ c. = 6/8/.. labor @ 1/8 = 1/15/..	
24	Ooday Raj _____ Valuation 500.0.0	6 rooms average 19⅓ x 8 - 1 roof tile rest kucha walls of mud 10 feet high, in bad order - 1 tile shed 21½ x 7'	1070 Sup feet @ 15/.. ₱ c. = 161/10/.. labor @ 3/.. = 32/5/..	
25	Ronga persaud _____ Valuation 500.0.0	6 rooms average 17¾ x 8¼ One roof kucha rest tile walls mud in bad order	866 Sup feet @ 10/.. ₱ c. = 86/10/.. labor @ 2/8 = 21/11/..	
26	Gendal _____	3 rooms — av — 22½ x 6 one tile roof open kucha, walls mud rest kucha	810 Sup feet @ 8/.. ₱ c. = 132/.. labor @ 2/8 = 16/4/..	

	Gundacan Valuation 500 " "	6 Rooms average 17'x7½ two kucha roofs, rest tiles, walls mud		527 Sup.t feet @ 9/"/- p.c = 4/7/1- labor @ 2/8/" = 13/2/-
28	Gungadeen — Do — 155 " " 0	6 — Do — Do — 17½ x 7½ two tile roofs, four kucha, — Do		761 Sup.t feet @ 5/"/- p.c = 38/"/- labor @ 2/"/" = 15/2/-
29	Goordial	3 rooms — Do — 20⅔ x 8' One tile roof, & four kucha, wall 63 feet long kucha		660 Sup.t Feet @ 20/"/- p.c = 132/"/- labor @ 3/"/" = 19/13/-
	Valuation 500 " " 0	pukka 8½ ft: high rest mud in bad order, one tile shed 20⅓ x 7'-		
30	Jungle Soobadar	12 rooms average 12'x7' two roofs kucha and the rest of mud.		1008 Sup.t Feet @ 8/"/- p.c = 80/"/- labor @ 2/"/" = 20/"/-
	Valuation 260 " " 0	in bad order, one tile shed 28⅓ x 7'.		
31	Seetul	6 rooms average 15'x7½ - two roofs tiles and four kucha - 2 sheds		662 Sup.t Feet @ 12/"/- p.c = 78/9/" labor @ 2/"/" = 13/"/-
	Valuation 500 " " 2	25'x6⅔ - walls mud 11 feet high, in bad order		
32	Sheopersaud & Cahee deen	7 Rooms average 17'x8' - 4 kucha and 3 tile roofs also 1 tile shed 17½ x 6¾		952 Sup.t Feet @ 15/"/- p.c = 142/12/- labor @ 3/"/" = 28/"/-
	Valuation 500 " " 0	walls mud 11 feet high in bad order.		
33	Goordial Valuation — 0 " " 0	8 Rooms average 10½ x 7' - 4 kucha and 4 tile roofs, walls as in preceding		588 Sup.t Feet @ 10/"/- p.c = 58/12/" labor @ 2/"/" = 11/11/-
34	Gungolee (Absent)	1 Room 17'x9½ - roof kucha and one tile shed 17'x6½ — Ditto		429 — Do — @ — Do — = 42/14/" Do @ 2/8/" = 10/11/-

(Sd) G. W. Hutchinson Lieutenant
Ex: Engr 6th Div Ganges Canal

Attending the Committee

(Sd) John Eliot Lieutt:
Temporary Asst 6th Canals

(Sd) Geo: Sim Lieutt
Offg Ex: Engr Cawnpore

(Sd) G. Tronson Major — President

(Sd) F. Riddell Captain
(Sd) G. Siddons Captain
(Sd) R Wroughton Lieutt
(Sd) Nasirally
} Members

(Signed) T. Ashburnham Brigadier
Commanding the Station.

and Valuate certain buildings and property which come in the line required for the Ganges Canal through the Suddur Bazar and Cantonment. Cawnpoor 19th March 1851

5th Section

President Major C. Fraser

Members: Captain G. R. Siddons, Lieutenant R. Wroughton, Captain S. Riddell, Syud Nasir Alli Dep'y Magistrate

No:	Name of and Valuation by Owners.	Description	Remarks by the Committee
1	Bukhta — Valuation 100 0 0	3 rooms average 12'×6½' two of tile and one of Kucha roof mud walls, about 9' high in fair order also a tile shed 32½ × 6½	312 Sup'f feet @ 6/ p. per 100 = 18/12/ Labor @ 1/8/ = 4/9/
2	Baday and Bhowance — Valuation 400 0 0	7 rooms average 10¼'×7'. Six of tiled roofs. 3 of which one 2 Stories the rest Kucha, walls 11 feet high in fair order. a shed tiled roof 18'×3¾'.	717 Sup'f feet @ 12/ p 100 = 86/ Labor @ 3/ = 21/8/
3	Jumna Dass & Motee Ram — Valuation 1400 0 0	3 rooms average 10¾ × 10½ Kucha roofs walls 10 feet high of Kucha pukka in good order	Value = 750/ Labor 250/
4	Mechul — Valuation 400 0 0	8 rooms average 13½ × 6¼ - 4 of tiled roofs of which 2 are 2 stories and 4 of Kucha roof (One in ruins) mud walls 9 feet high in bad order, a shed. tile roof 20½ × 6'.	843 Sup'f feet @ 10/ p 100 = 84/4/ Labor @ 3/ = 25/5/
5	Dherdug — Valuation 0 0 0	House in ruins	No property only ground.
6	Sheropersad — Valuation 700 0 0	8 rooms average 16¼ × 6¾' - four of which tiled. 2 of 2 stories and 4 Kucha roofs (One in ruins, mud walls 9 feet high, also a tile shed 16¾' × 5½'.	1096 Sup'f feet @ 8/ p 100 = 87/10/ Labor @ 2/0/ = 27/5/
7	Gareel Doss — Valuation 900 0 0	7 rooms average 10½ × 7½ - three of tiled and one of Kucha roofs mud walls 10 feet high, a tile shed 29¾' × 5 3/4'.	1387 Sup'f feet @ 12/ p 100 = 166/ Labor @ 3/ = 41/9/
8	Chainsookh — Valuation 700 0 0	12 rooms 13¼ × 7 1/3 - five of tile roofs - 3 of which 2 stories and 7 of Kucha. mud walls 10 feet high in good order a tile shed 28' × 5¾'.	1643 Sup'f feet @ 16/ p 100 = 262/14/ Labor @ 4/ = 65/11/
9	Bis Ram — Valuation 250 0 0	4 rooms. 12 × 7¾' - two of tiles and two of Kucha roofs. mud walls 9 feet high, in bad order, a tile shed 12 × 6'.	465 Sup'f feet @ 10/ p 100 = 46/8/ Labor @ 2/ = 9/5/
10	Binda Ram — Valuation 200 0 0	4 rooms 11 × 8¼' - 2 of tile and 2 of Kucha roofs, Mud walls 9 feet high in bad order, a tile shed 13½ × 6'	453¾ Sup'f feet @ 10/ p 100 = 45/5/ Labor @ 2/ = 9/

Ganges Canal

Appendix R R Vol III

	Valuation 405„0„0	6 S kucha roofs, one S which also has 2 stories, mud walls 12 feet high in fair order, and shed 17¾ x 6.	750 Sup Feet @ 15/„/„ ₱ ₰ = 112/8/„ Labor @ 4/„/„ = 30/„/„
12	Lsoondial	5 Rooms average 11½ x 7'- 3 S tiles and 4 S kucha roofs mud-	805 Sup Feet @ 10/„/„ ₱ ₰ = 80/5/„ Labor @ 3/„/„ = 24/„/„
	Valuation 600„0„0	walls 9' high, in fair order, a tile shed. 23½ x 6'.	
13	Shew Lall	5 Rooms 17½ x 7½ - One S kucha. four tiled roofs, mud walls 9 feet	787 Sup Feet @ 7/„/„ ₱ ₰ = 55/1/„ Labor @ 2/„/„ = 15/12/„
	Valuation 300„0„0	high, in fair order, 1 tile shed 23' x 6'.	
14	Kunhee	10 Rooms 16¾ x 7'- 4 S tiled & 6 S kucha roofs mud walls about 10 high in	1289 Sup Feet @ 12/„/„ ₱ ₰ = 154/10/„ Labor @ 3/„/„ = 38/10/„
	Valuation 350„0„0	fair order, front pillars S kucha Pukka, a tiled shed 29½ x 6'	
15	Shew pershaud	1 Room 14 ⅓ x 5¾ kucha roof, Mud Walls 9½ feet high, in	82 Sup Feet @ 15/„/„ ₱ ₰ = 12/4/„ Labor @ 2/„/„ = 1/10/„
	Valuation 30„0„0	bad order	
16	Sollah	6 Rooms average 12¾ x 6'- 2 S tile and 4 S kucha roofs also 2	535 Sup Feet @ 6/„/„ ₱ ₰ = 32/2/„ Labor @ 1/8/„ = 8/„/„
	Valuation 50„0„0	sheds kucha roofs, supported on wooden posts 15' x 15' and a grass	
		shed 20' x 6'- Mud walls 9 feet high, in bad order	
17	Koosall	15 Rooms average 11½ x 6½ - 4 S kucha and 11 S tile roofs, mud walls	1121 Sup Feet @ 7/„/„ ₱ ₰ = 78/7/„ Labor @ 2/„/„ = 22/6/„
	Valuation 100„0„0	7' high in bad order	
18	Mookeembeg	1 Room 12' x 5⅜' kucha roof, 2 tile sheds 15' x 11¾', mud walls. One	Valuation = 150/„/„ Labor = 50/„/„
	Valuation 200„0„0	wall (14' x 10' x 1½') kucha pukka, in bad order	
19	Piarree	7 rooms average 9¾ x 6'- 1 S tiled 6 S kucha roofs, mud walls 7'	409 Sup Feet @ 7/„/„ ₱ ₰ = 28/10/„ Labor @ 2/„/„ = 8/„/„
	Valuation 40„0„0	high, in bad order.	
20	Roodhoo Khan	3 rooms average 21¾ x 7'0"- 1 S kucha 2 tile roofs, mud walls	190 Sup Feet @ 12/„/„ ₱ ₰ = 59/„/„ Labor @ 3/„/„ = 14/15/„
	Valuation 350„0„0	8' high, in bad order.	
21	Buldeo and Mewazee	2 rooms 11' x 6½' kucha roofs, a tiled shed 16¾ x 6½ - mud walls	175 Sup Feet @ 15/„/„ ₱ ₰ = 26/4/„ Labor @ 2/„/„ = 3/8/„
	Valuation 175„0„0	9' high, in bad order.	

2	22	Kungor 2 L 257, IV. 3. Valuation 100,,0,,0	1 room 13½ × 8½' kucha roof a tile shed 15 × 12¾ mud walls 9' high in bad order	229 Sup. feet @ 15/,,/ ₱ % = 34/3/,, labor @ 2/,,/,, = 4/3/,,
2	23	Burkha Valuation 200,,0,,0	7 rooms average 14½ × 6½ - 1 tiled and the rest kucha roof, one 2 storied, mud walls 10' high in bad order	725 Sup. feet @ 7/,,/,, ₱ % = 50/12/,, labor @ 2/,,/,, = 14/5/,,
2	24	Jogpal Valuation 100,,0,,0	7 rooms average 16½' × 7½' - 3 of tiled and 4 of kucha roofs mud walls 9' high, in bad order.	853 Sup. feet @ 5/,,/,, ₱ % = 42/9/,, labor @ 2/,,/,, = 17/,,/,,
2	25	Puchkouree Valuation 40,,0,,0	3 rooms 10 × 6⅔', one of grass 2 storied and two of tiles also a shed 8 × 4¾', mud walls 9' high in bad order.	264 Sup. feet @ 7/,,/,, ₱ % = 18/7/,, labor @ 2/,,/,, = 5/2/,,
2b		Jemadar Hakeera Valuation 65,,0,,0	2 rooms 15¼ × 8' kucha roofs and a grass shed, mud walls 9' high in bad order	255 Sup. feet @ 7/,,/,, ₱ % = 25/9/,, labor @ 2/,,/,, = 7/5/,,
27		Beera Valuation 40,,0,,0	2 rooms 18¼ × 7½' tiled roofs, mud walls 8' high in fair order	273 Sup. feet @ 7/,,/,, ₱ % = 19/1/,, labor @ 2/,,/,, = 5/7/,,
28		Ramdial Do 60,,0,,0	3 Do average 10½ × 7⅓' Do Do Ditto	566 Do @ Do = 39/9/,, Do Do = 11/5/,, 4 rooms
29		Bhowanee	2 Do 10¾ × 8¼' thatched Do 5' high	Value = 8/,,/,, labor = 2/,,/,,
30		Rutnee	1 Do 14½ × 7' Do Do Do 2 sides grass on other 2 in bad order	Value = 4/,,/,, labor = 2/,,/,,
31		Abdool Raheem Valuation 15,,0,,0	4 rooms average 13¾ × 6½ - 3 tiled roofs one 2 storied and 1 kucha roof also 2 sheds 11¼ × 7½ mud walls 10' high in bad order	555 Sup. feet @ 8/,,/,, ₱ % = 44/8/,, labor @ 2/8/,, = 13/4/,,
32		Alleebux Valuation 300,,0,,0	4 rooms 9¾ × 6' - 2 of 2 stories tiled roofs and 2 of kucha a small room 4¾ × 5 with tiled roof, mud walls 12' high in good order also a shed 11½ × 7'.	468 Sup. feet @ 15/,,/,, ₱ % = 70/3/,, labor @ 3/,,/,, = 14/,,/,, (upper stories)
33		Uzmut Khan Valuation 200,0,0	4 rooms average 10¾ × 7¼' 2 of kucha and 2 of tile roofs, mud walls, 8 feet high, in fair order.	426 Sup. feet @ 15/,,/,, ₱ % = 63/14/,, labor @ 3/,,/,, = 12/,,/,, (upper stories)

34	Caadee and Lingadeen — Valuation — 120„0„0	4 rooms average 9½×6½ - 2 of kucha and 2 of tiles roof 2 stories high mud walls 12' high in bad order	384 Sup Feet @ 10/„ ℔ ℅ = 38/6„ labor @ 2/8„ = 9/9„	
35	Mukha — Ido — 60„0„0	4 rooms Average 11×7' kucha roofs mud walls 9 feet high in fair order	350 Sup Feet @ 8/„ ℔ ℅ = 28/„ labor @ 2/„ = 7/„	
36	Kureem (absent)	1 room 15¾×7½' tiled roof a tiles shed 12×6' mud walls. 8' high in bad order	114 — Ido — Ido = 9/1„ — Do @ 1/8„ = 1/11„	
37	Bhowaneedeen Valuation 200„0„0	4 rooms Average 10×5¾ kucha roofs, mud walls 9' high in fair order	315 — Ido — @ 30/„ ℔ ℅ = 103/8„ — Ido @ 5/„ = 17/4„	
38	Lall Mahomed — Ido — 150„0„0	4 rooms 8½×6½ kucha roofs. mud walls 9' high — Ido	306 — Ido @ 20/„ ℔ ℅ = 77/3„ — Ido @ 4/„ = 15/7„	
39	Kureemmm — Valuation 60„0„0	1 room 15½×7½ kucha roof 2 tile sheds 16½×6½ mud walls 9' high in fair order	336 — Ido @ 8/„ ℔ ℅ = 26/14„ — Ido @ 2/„ = 6/11„	
40	Hodassie — Ido — 80„0„0	2 rooms 15¼×10' - 1 of tile the other of kucha roof and mud walls — Ido — Ido	305 — Ido @ — Ido — = 24/6„ — Ido @ Do = 6/1„	
41	Abdoolla — Valuation 500„0„0	12 Do Average 12½×7⅛ - 4 of tile 8 of kucha roofs Mud walls 12' high in fair order	1099 — Ido @ 20/„ ℔ ℅ = 219/12„ — Ido @ 5/„ = 54/15„	
42	Shumdee Mul — Absent	2 rooms 17×7¾ - 1 tiled and the other thatched mud walls. 6' high in bad order.	263 Ido @ 5/„ ℔ ℅ = 13/2„ labor @ 1/8„ = 3/13„ Gardners house only.	
43	Lallah Valuation 25„0„0	1 room 12¾×10½ kucha roof, mud walls, about 6' high in bad order	133 Sup Feet @ 10/„ ℔ ℅ = 13/5„ labor @ 2/8„ = 3/5„	

(Signed) L. W. Hutchinson Lieutt
Ex: Engr 6th Dv Ganges Canal

Attending the Committee

(Sgd) John Eliot Lieutt:
Temporary assistt: Ganges Canal

(Sgd) Geo: Sim Lieutenant
Offg Ex: Engr 1st Dv P. Works

(Signed) L. Prowse Major — President
(Signed) F. Riddell Captain
(Signed) C. K. Siddons Captain
(Signed) R. Broughton Lieutenant
(Signed) Nasir Alli
} Members

(Signed) P. Ashburnham Brigadier
Commanding the Station

Valuate certain buildings and property which come in the line required by the Gunges Canal through the Suddur Bazar and Cantonment Cawnpoor 18th March 1837

4th Section

President Major C. Prouse

Captain G.R. Siddons, Lieutenant R. Wroughton } Members { Captain P. Riddell, Syud Nasir Alli Deputy Magistrate

4a

No	Names of and Valuation by Owners.	Description	Remarks by the Committee
1	Bareeram & Gungadeen (Absent)	2 rooms average 18'x8¾' one of tile and the other of kucha roof. walls of kucha Pukka Masonry about 9 feet high in fair order	Owner not present. 311 Sup.feet @ 10/"/" ₱ 100 = 31/2/" Labor @ 2/"/" = 7/12/"
2	Nungoo Valuation 1200"0"0	14 rooms average 10½'x7' of kucha roof. 6 of these are 2 story 3 of kucha Pukka masonry and the rest of mud about 9½ feet high in very bad order. also 2 tile sheds 11½'x7⅓'.	1470 Sup feet @ 6/"/" ₱ 100 = 73/8/" = Labor @ 2/"/" = 29/6/"
3	Monjee Ram (Absent)	4 rooms Average 15'x9½' two of Pukka roof 2 story high and the rest of kucha, walls kucha Pukka Masonry 11¼ feet high, in fair order, also one tile shed 23'x7⅓'	855 Sup feet = 400/"/" Labor = 100/"/"
4	Thakoordoss Valuation 500"0"0	7 Rooms Average 17¼'x6½' of kucha roof, walls of Mud. 10½ feet high, in bad order.	739 Sup feet @ 8/"/" ₱ 100 = 61/5/" Labor @ 2/8/" = 18/7/6
5	Deena Valuation 2000"0"0	9 rooms average 9⅓'x6⅓' three of tile roof and the rest of pukka, walls of 3 rooms of pukka kucha masonry and the rest of mud 10¼ feet high in fair order. one tile shed 20½'x7¼'	Value = 250/"/" Labor = 80/"/"
6	Khemanund and Gungabishun Valuation 4000"0"0	4 rooms average 17½'x7½' two of tile roof and two story and the rest of Pukka roof. Walls of kucha pukka masonry 11¼ feet high in fair order, one tile shed 20½'x7½'.	Value = 500/"/" Labor = 130/"/"
7	Ramdial Valuation 400"0"0	15 rooms average 16½'x6½' two of tile roofs 2 story high and the rest of pukka and kucha roofs, wall about 151 feet long and 10¼ feet high of kucha pukka masonry, the rest of mud in good order	Value = 320/"/" Labor 100/"/"
8	Rimmoot Ram Valuation 7000"0"0	10 rooms average 16½'x8½'. Six of pukka roofs, 2 story high, walls of kucha Pukka Masonry one side pukka plastered	Value = 2300/"/" Labor = 766/"/"

Cawnpoor 24th May 1853.

Number	Name of Owners	Owner's Valuation Rs	Owner's Valuation As/Pie	Board's Valuation Rs	Board's Valuation As/Pie	Nature and extent of Buildings	Nature of Roof &c.a	Rate	Remarks by the Board
1	Lallmeerkhan			65		320 Sup.ft Kc. Pukka	Flat Mud on Kurries	20 Rs p o/o Sup.feet	7a
2	Ditto	800		25	10	320 Sup.ft Kc. 2 Rooms	Tiled on Kurries	8 Rs p o/o Sup.feet	
3	Gungadeen	200		41	10	320 Sup.feet Kucha	Flat Mud and leanto Tile on Kurries	8 Rs p o/o Sup.feet	
4	Muddun Mohun	500		40		500 Sup.feet Kucha	Flat Mud on Kurries	8 Rs p o/o Sup.feet	
5	Deokanundun	25		22	8	450 Sup.feet Kucha	Flat bad repair	5 Rs p o/o Sup.feet	
6	"	"	"	"	"	Chuppers to be removed			
7	Khunnani	"	"	30		600 Sup.feet Kucha	Flat and leanto Tile woodwork of inferior description	5 Rs p o/o Sup.feet	
8	Mudun	"	"	22		440 Sup.feet Kucha	Do Do Do	5 Rs p o/o Sup.feet	
9	Jumna Dos	"	"	40	10	580 Sup.feet Kucha	Do Do on Kurries, good repair	7 Rs p o/o Sup.feet	
10	Mahomed Khan	"	"	46	3	680 Sup.feet Kucha	Flat and Chuppers Ditto & Ditto	7 Rs p o/o Sup.feet	
11	Nunna	"	"	12	4	204 Sup.feet Kucha	Flat Mud on Kurries	6 Rs p o/o Sup.feet	
12	Sewa	"	"	25		250 Sup.feet Kucha	Thatched 2 stories	10 Rs p o/o Sup.feet	
13	Sewa	"	"	3		A well Kucha	3 feet at top pukka		
14	Kushyal Seli	"	"	67	14	968 Sup.feet Kucha	Flat and leanto Tile on Kurries	7 Rs p o/o Sup.feet	
15	Meryo	"	"	31		620 Sup.feet Kucha	Flat Mud with Tile & Thatch leanto Do. wood work inferior description	5 Rs p o/o Sup.feet	
16	Nuthoo	125		68		880 Sup.feet Kucha	Flat and leanto tile on kurries Good repair	8 Rs p o/o Sup.feet	
17	Bhawani	150		94		1280 Sup.feet Kucha	Tiled on Kurries	1000- 8 p o/o Sup.feet; 280- 5 p o/o Sup.feet	
18	Doorjun	"	"	48		150 Sup.feet Kucha	Thatched bad repair	3 Rs p o/o Sup.feet	

20	Deena	"	"	"	36	"	"	600 Sup.Feet Kucha	Tiled	6 Rs ℘ ℘ Sup.Feet
21	Khodabux	"	"	"	27	8	"	500 Sup.Feet Kucha	Tiled inferior wood work	5/8 Rs ℘ ℘ Sup.Feet
22	Baddulee	"	"	"	19	"	"	380 Sup.Feet Kucha	Flat Mud and Leants Tile do do	5 Rs ℘ ℘ Sup.Feet
23	Poonun	"	"	"	60	"	"	750 Sup.Feet Kucha	Flat Mud and Leants Tiled on Kunnies	8 Rs ℘ ℘ Sup.Feet
24	Subsookh	"	"	"	70	"	"	1000 Sup.Feet Kucha	Ditto Ditto Ditto	7 Rs ℘ ℘ Sup.Feet
25	Pulloo	"	"	"	36	"	"	450 Sup.Feet Kucha	Flat on Kunnies	8 Rs ℘ ℘ Sup.Feet
26	Moolla	"	"	"	12	"	"	300 Sup.Feet Kucha	Chuppur and Tiled out of repair	4 Rs ℘ ℘ Sup.Feet
27	Narain	"	"	"	30	"	"	250 Sup.Feet Kucha	Flat on Kunnies. Roof and Building generally well constructed	12 Rs ℘ ℘ Sup.Feet
28	Bissumber	"	"	"	68	"	"	700 Sup.Feet Kucha	Flat and Leants Tile. good repair, Pukka Brick floor & plinths at Doorway	300 @ 16 Rs ℘ ℘ Sup.Feet 400 @ 5 Rs ℘ ℘ Sup.Feet
29	Subsukh	"	"	"	18	9	"	310 Sup.Feet Kucha	Flat & Leants thatched, inferior woodwork	6 Rs ℘ ℘ Sup.Feet
30	Kaee Aheer	"	"	"	24	12	"	310 Sup.Feet Kucha	Flat on Kunnies in good repair	8 Rs ℘ ℘ Sup.Feet
31	Subba Aheer	"	"	"	19	9	"	280 Sup.Feet Kucha	Flat and Leants Tile	7 Rs ℘ ℘ Sup.Feet
32	Cheda	"	"	"	17	8	"	250 Sup.Feet Kucha	Ditto Ditto	7 Rs ℘ ℘ Sup.Feet
33	Mukha	"	"	"	35	"	"	500 Sup.Feet Kucha	Ditto Ditto	7 Rs ℘ ℘ Sup.Feet
34	Luchee Bunnia	"	"	"	21	"	"	300 Sup.Feet Kucha	Ditto Ditto	7 Rs ℘ ℘ Sup.Feet
	Carried forward				1,179	1	"			
					161					

	Brought forward	3		11791		9	17	4		
35	Chedi Boorja	"	"	76	"	950 Sup.feet kucha	Flat and leanto tile on kunies	8 Rs ℔ % Sup.feet		7c
36	Cheda Amar	"	"	150	"	600 Sup.feet kucha	2 Stories, with tiled open court in Centre, in Good repair & well built Veranda rest aroad	25 Rs ℔ % Sup.feet		
37	Khoosial Boodawala	"	"	135	"	850 Sup.feet kucha	Partly 2 Stories, tiled, a Boorsa shed; dem ken floor, Pukka lines, pukka chams on house	15 Rs ℔ % Sup.feet		
38	Kulla	"	"	.	"	Not valued ℔ Qu.				
39	Mummeram	"	"	6	12	444 Sup.feet kucha	Sheds in bad repair	1 Rs ℔ % Sup.feet		
40	Mumbhur	"	"	250	"	1016 Sup.feet part Rubble & p. Pukka	With Court in centre well built, flat mud and leanto tile with stair case.	25 Rs ℔ % Sup.feet		
41	Kanjee Mull	"	"	500	"	1050 Sup.feet kucha Pukka.	2 Stories, flat cont in Centre, double Stair Case well built and in repair	48 Rs ℔ % Sup.feet		
42	Punchum Dirgee	"	"	17	9	220 Sup.feet kucha	Flat, repair good	8 Rs ℔ % Sup.feet		
43	Deena	"	"	126	"	1400 Sup.feet kucha	Flat mud and leanto Tile, and thatched partly double stories.	9 Rs ℔ % Sup.feet		
44	Salis pam	"	"	21	"	300 Sup.feet kucha	Tiled.	1 Rs ℔ % Sup.feet		Rs 150 0
45	Chuttri	12,000	"	3000	"	2,000 Sup.feet Pukka	2 Stories with enclosed Court also veranda, whole very well built, good repair. Flat Pukka	150 Rs ℔ % Sup.feet		
46	Motee	"	"	105	"	1500 Sup.feet kucha	Flat Mud and leanto Tile	7 Rs ℔ % Sup.feet		
47	Lalla Bimmiya	"	"	38	6	320 Sup.feet kucha	2 Stories & flat, & leanto tile well built	12 Rs ℔ % Sup.feet		
48	Buldeo Chokee	"	"	19	13	330 Sup.feet kucha	Flat	6 Rs ℔ % Sup.feet		
49	Soomboo	"	"	10	"	200 Sup.feet kucha	Tiled inferior Woodwork	5 Rs ℔ % Sup.feet		
50	Rukhee	"	"	12	8	250 Sup.feet kucha	Flat and Shed Do Do	5 Rs ℔ % Sup.feet		
51	Narain	"	"	30	"	500 Sup.feet kucha	Flat and leanto tile	6 Rs ℔ % Sup.feet		

52	Chiami	"	"	"	16	8	165 Sup.t feet kucha	Tiled 2 Stories	10 Rs ₹ ℅ Sup.t feet
53	Gungolie	"	"	"	24	"	400 Sup.t feet kucha	Flat and leanto Tile	6 Rs ₹ ℅ Sup.t feet
54	Ajoodia	"	"	"	58	13	820 Sup.t feet kucha	—do— Co— good repair	7 Rs ₹ ℅ Sup.t feet
55	Babooram	"	"	"	66	"	330 Sup.t feet kucha	Part 2 Stories, Flat, good repair	20 Rs ₹ ℅ Sup.t feet
56	Dhoondi	"	"	"	214	"	1070 Sup.t ft. do one wall kopa	Part 2 Stories Flat, Centre Court & Staircase good	20 Rs ₹ ℅ Sup.t feet
57	Seopershad	"	"	"	70	3	1170 Sup.t feet kucha	Tiled	6 Rs ₹ ℅ Sup.t feet
58	Khoori	"	"	"	18	"	300 Sup.t feet kucha	Tiled	6 Rs ₹ ℅ Sup.t feet
59	Muthura	"	"	"	42	"	350 Sup.t feet kucha	Part 2 Stories. Flat and leanto Tile	12 Rs ₹ ℅ Sup.t feet
60	Lalla	"	"	"	35	"	500 Sup.t feet Kucha	Flat	7 Rs ₹ ℅ Sup.t feet
61	Bhowanee	"	"	"	28	"	400 Sup.t feet kucha	Flat	7 Rs ₹ ℅ Sup.t feet
62	Bhoop	"	"	"	28	"	400 Sup.t feet Kucha	Flat and leanto tile	7 Rs ₹ ℅ Sup.t feet
63	Beeda	"	"	"	27	8	550 Sup.t feet kucha	Low tiled	5 Rs ₹ ℅ Sup.t feet
64	Ramdial	"	"	"	45	"	300 Sup.t feet kucha	2 Stories. Flat and leanto tile	15 Rs ₹ ℅ Sup.t feet
65	Bawani Kunjoo	"	"	"	15	"	250 Sup.t feet Kucha	Tiled	6 Rs ₹ ℅ Sup.t feet
66	Ruttunee	"	"	"	6	"	100 Sup.t feet Kucha	Tiled	6 Rs ₹ ℅ Sup.t feet
67	Bhola	"	"	"	24	"	300 Sup.t feet kucha	Tiled over Flat	8 Rs ₹ ℅ Sup.t feet
68	Thakoorda	"	"	"	54	"	600 Sup.t feet Kucha	Flat and steps good	9 Rs ₹ ℅ Sup.t feet
69	Poorun	"	"	"	52	8	750 Sup.t feet kucha	Flat and thatched	7 Rs ₹ ℅ Sup.t feet
	Carried forward				6,501	9	"		

70	Brought forward 10	3		6501 4½	9	9	17	4	
70	Baynee	"	"	72	"	600 Sup Feet Kucha	Flat and yard good repair	12 As ℔ % Sup Feet	7 e
71	Newdeen	"	"	69	"	1550 Sup Feet Kucha	Flat and tiled	6 As ℔ % Sup Feet	
72	Ramdeen	500	"	160	"	1000 Sup Feet Kucha	Flat and tiled 2 Stories Good	16 As ℔ % Sup Feet	
73	Woolassi	"	"	10	"	400 Sup Feet Kucha	Flat 2 Stories	10 As ℔ % Sup Feet	
	Total Cost Rupees			6,842	9				
	Left Bank								
	Brought forward			6842	9				
74	Gungoo	"	"	70	"	700 Sup Feet Kucha	Flat Leanto tile good woodwork	10 As ℔ % Sup Feet	
75	Buldoo Newazee	"	"	60	"	600 Sup Feet Kucha	Do Do Do	10 As ℔ % Sup Feet	
76	Budhoo Khan	"	"	92	"	1200 Sup Feet Kucha	Tiled	700-6 500-10 As ℔ % Sup Feet	
77	Summa Doss	"	"	1000	"	2250 Sup Feet Kucha &c	2 Stories with Cutcherry Court. Flat, mud with staircase, in good repair		
78	Valued and taken by former Committee								
79	Bukhtee	"	"	18	"	600 Sup Feet Kucha	Flat and leanto tile on good Woodwork with steps	8 As ℔ % Sup Feet	
80	Russool	"	"	70	"	1000 Sup Feet Kucha	Tiled and Flat on Do Do	7 As ℔ % Sup Feet	
81	Gungaram	"	"	768	"	850 Sup Feet Kucha	Flat	7 As ℔ % Sup Feet	
82	Meeroo	"	"	36	"	450 Sup Feet Kucha	Flat and leanto tile good woodwork	8 As ℔ % Sup Feet	
83	Moona Lall	"	"	63	"	700 Sup Feet Kucha	Flat mud with Cutcherry and steps	9 As ℔ % Sup Feet	

85	Thakoordass	"	"	"	200	"	"	500 Sup.ft. K.a Pukka	Flat and beamts tile	1.0 Rs ℔ ℅ Sup.feet
86	Ditto	"	"	"	15	"	"	120 Sup.feet Kucha	Tiled	12/8 Rs ℔ ℅ Sup.feet
87	Chuttri	"	"	"	600	"	"	750 Sup.feet K.a Pukka	2 Stories flat and beamts tile, with steps, well built and in good repair. with brick paved flooring.	80 Rs ℔ ℅ Sup.feet
88	Roshun Lall	"	"	"	180	"	"	400 Sup.feet K.a Pukka	2 stories, Flat and tiled with do flooring	1.5 Rs ℔ ℅ Sup.feet
89	Lall mmv	"	"	"	161	8	"	950 Sup.ft. ℔ C.o.t pt. do	Flat well built.	1/ Rs ℔ ℅ Sup.feet
90	Ramdeen	1000	"	"	35	"	"	350 Sup.feet K.a Kucha	Flat an Kunnies	10 Rs ℔ ℅ Sup.feet
91	Buldeo	5000	"	"	600	"	"	750 Sup.feet K.a Pukka	Flat and warehouses, with brick paved floors. whole very well built, & nearly new.	80 Rs ℔ ℅ Sup.feet
92	Rampershad	"	"	"	21	"	"	300 Sup.feet Kucha	Flat and beamts tile	7 Rs ℔ ℅ Sup.feet
93	Sheikh Madarbux	"	"	"	16	"	"	400 Sup.feet Kucha	Walls alone standing	1. Rs ℔ ℅ Sup.feet
94	Rampershad	"	"	"	50	"	"	500 Sf.t. Outer P.a Imm K.a	Flat	10 Rs ℔ ℅ Sup.feet
95	Mihee Lall	"	"	"	27	"	"	450 Sup.feet Kucha	Flat and tiled	6 Rs ℔ ℅ Sup.feet
96	Lalla Mull	"	"	"	126	"	"	1050 Sf.t. Outer P.a Imm K.a	Flat and tiled with steps.	12 Rs ℔ ℅ Sup.feet
97	Degram Lohar	"	"	"	24	"	"	400 Sup.feet Kucha	Flat and tiled	6 Rs ℔ ℅ Sup.feet
98	Kassiram	"	"	"	14	"	"	200 Sup.feet Kucha	do — do — steps	7 Rs ℔ ℅ Sup.feet
99	Mungul Sen	"	"	"	20	"	"	250 Sup.feet Kucha	Flat.	8 Rs ℔ ℅ Sup.feet
100	Thatched Sheds	not Valued								
101	Gungapershad	"	"	"	40	"	"	400 Sup.feet Kucha	2 stories Tiled	10 Rs ℔ ℅ Sup.feet
102	Dulla	"	"	"	54	"	"	450 Sup.feet Kucha	Flat well built	12 Rs ℔ ℅ Sup.feet
	Carried Over				11,041	9	"			

	Brought forward		11,041	9				
103	Gungapershad		66		550 Sup.l feet kucha	2 Stories tiled	12 Rs. pp % Sup.l feet	
104	Sumbhoo		25		250 Sup.l feet kucha	2 Stories tiled	10 Rs pp % Sup.l feet	
105	Bodha		120		400 Sup.l ft. p.t do p.t Pukka	Flat and steps, good repair	30 Rs pp % Sup.l feet	
106	Hiyat khan		43	6	620 Sup.l feet kucha	Tiled	7 Rs pp % Sup.l feet	
107	Rokhmun		52	"	650 Sup.l feet kucha	Part 2 Stories, tiled	8 Rs pp % Sup.l feet	
108	Rampershad		12	10	180 Sup.l feet kucha	Tiles	7 Rs pp % Sup.l feet	
109	Chundun		66	"	550 Sup.l feet kucha	2 Stories, tiled	12 Rs pp % Sup.l feet	
110	Bhujja		38	8	550 Sup.l feet kucha	2 Stories, tiled, old	7 Rs pp % Sup.l feet	
111	Ossaree		58	8	650 Sup.l feet kucha	2 Stories, tiled	9 Rs pp % Sup.l feet	
112	Mahadook		125	"	1250 Sup.l feet kucha	Tiled.	10 Rs pp % Sup.l feet	
113	Ummun Sing		18	"	300 Sup.l feet kucha	Tiled sheds	6 Rs pp % Sup.l feet	
114	Ditto		24	"	400 Sup.l feet kucha	Tiled sheds	6 Rs pp % Sup.l feet	
115	Ditto		938	"	3360 Sup.l ft. Outer p.t Inner ka.	Flat mud roof, leanto tiled do. below 26 Rooms forming range of 7 Shops Pukka Parapets, whole well built.	28/8 Rs pp % Sup.l feet	
	Total Cos: Rs.		12,648	9	Total Valuation of buildings required in General Sums.-			
	Brought forward		12,648	9				
116	Mussl Ulmeenin's Estate	1,000	"	500	"	A flat roofed house, containing 2 rooms with tiled Verandah, walls kucha. area of Building 56 x 10' in bad repair.		

19

						A tiled building 1 large and 7 small rooms 65'×55'
117	Nunna Nowalis Estate	Not present	600	"	"	Roof of single tiles with light woodwork, and not in good order. Doors ditto
118	— Do: — Do		1,400	"	"	A thatched building 2 large and 8 small rooms with Veranda all round, area 68'×65' with tiled out Office attached 78 feet longly 12 broad. The Whole in good repair.
119	Mr. Reid's Estate	3,000	2,500	"	"	A tiled bungalow 9 rooms, with Verandah all round, area of building 80'×68', in good repair and well fitted in the interior range of Stabling, and out Offices in the Compound
120	Nawal Roshun Nowalis Estate	Not present	2500	"	"	A Terrace roofed building 4 rooms with enclosed Verandah, and on one side an Open one beyond this, area of Whole building 75'×63' Walls of Pela Brick with puttka Plaster, much injured by weather in parts. Venetians to 18 Outside doors, all woods in bad repair. Range of Mud roofed outhouses, Walls Pela Bricks in Mud 100'×12'. 2 Ranges of tiled ditto. Total length 180 feet by 12 feet broad.
			20,108	9		
	Carried forward		20,148	9	"	

7 h

	Brought forward				20,148	9	"			
	Golah Ghat									
121	Kurreem Bux		"	"	56	"	"	800 Sup.l feet kucha	Flat and leanto thatched	1 Rs: fp % Sup.l feet
122	Gunga Bidun	1,000	"	"	2,000	"	"	2440 Sup.l feet Pukka	2 Stories with Centre Court flat Pukka, whole well built and in good repair.	
123	Budhipershad Beparie	5,000	"	"	400	"	"	940 Sup.l feet kucha pukka	Pukka flat with leanto tile do. wood work & roof turrets Old & decayed Masonry of walls rough & without finish. the building being only Timber, stores and workshops.	
124	Buleo		"	"	40	"	"	400 Sup.l feet Kucha Pukka	Leanto tile against wall of last building	10 Rs fp % Sup.l feet
125	Ishundee		"	"	24	"	"	400 Sup.l feet kucha	Flat leanto tile and thatched	6 Rs fp % Sup.l feet
126	Ghasee		"	"	50	"	"	1000 Sup.l feet kucha	Flat leanto tile on bad woodwork	5 Rs fp % Sup.l feet
127	Moona Ghaseta	500	"	"	180	"	"	800 Sup.l feet Kucha Pukka 22 R.g feet Pukka	Flat and leanto tile. Retaining walls three feet thick and steps on River edge.	16 Rs fp % Sup.l feet 2 Rs fp Running foot
	Grand Total Cost Rs				22,898	9	"	Total of Valuation		

Attending the Board

(Signed) Charles I Hodgsin Lieut.
Ex: Engr: 4th N.D.S. canals

(Signed) Geo: Sim Lieutenant
Offg Exec: Engr: 4th Div.

President (Signed) T. J. Bradford Lieut Col: C.B.

Members
(Signed) J. Riddell Captain
(Signed) G. S. Bowring Captain
(Signed) Stewart Graham Lieutenant
(Signed) Nasir Ally

(Signed) J. Palmer Brig.r General

4th Section

...ney and valuate certain buildings and property which come in the line required for the Ganges Canal, through the Suddur Bazar and Cantonment — Cawnpoor 26th March 1851

— 1st Section —

— President — Major C. Fronp —

Captain C. Boulton, Lieutenant R. Wroughton } — Members — { Lieutenant C. Warde, Syud Nasir Alli Khan Dy Magistrate

No.	Names of and Valuation by Owners.	Description	Remarks by the Committee
1	Ramdeen — Valuation 25.000.0.0	12 Rooms average 19 3/6 x 10 3/4. 3 of Kucha roof and the rest of tile, walls of Mud about 10½ feet high and 3 sheds 11 x 3½ 2 of Grass and one of tile in bad order. also a temple containing 2 rooms average 16 3/4 x 9½, and a Verandah 15½ x 7 3/4 of Pukka Masonry, Pukka Plastered on both sides and 2 stories high, total height 25 feet, roof Pukka and in very good order, also a Pukka Kucha well, diameter 3½ feet.	Temple @ 7.400.0.0 Labor @ 2.400.0.0 2909 S. feet out Offices @ 10/.../. ₹ 100 - 290/-/- Labor - 70/-/-.
2	Nabab Roshunooddoulah — Valuation — " " "	24 Rooms average 15½ x 9 3/4 - 11 of tile roof and 10 of Grass and 3 with a frame of bamboos with no grass ₹ on them walls of mud with the exception of 22 pillars 2½ x 2½ which are of Pukka masonry, about 10 feet high, also 6 sheds average 22 x 10 - 3 of tile and 3 of Grass. Whole in bad order.	Stables - 1200.0.0. Out Offices huts ₹ = 342.0.0 Gateway - 125.0.0 = 1667.0.0 - Labor - 400.0.0
3	Gholamrussool and Shubratally. — 160.0.0	1 Room 10 3/3 x 7½ of Kucha roof - Walls of mud, about 8 feet high in bad Order.	135 S feet @ 8/-/- ₹ 100 - 10/12/- Labor @ 2/-/- = 4/12/-
4	Ukburally — Valuation — 200.0.0	2 Rooms average 12½ x 9½ of tile roof - walls of mud. about 6½ feet high. in bad order.	237 Sq: feet @ 7/-/- ₹ 100 - 16/9/- Labor @ 2/-/- - 4/12/-
5	Uzmut ally — Valuation — 150.0.0	2 Rooms average 12 x 7½. 1 of tile roof. 2 stories high and the other of tile Roof.	270 Sq: feet @ 10/-/- ₹ 100 - 27/-/- Labor @ 2/8/- = 6/12/-
6	Badoollah — Valuation — 175.0.0	1 Rooms average 8½ x 7 3/4 one of Kucha roof and 3 of tile. 2 story high walls of Pukka Kucha Masonry 10 feet high in good order.	160 Sq: feet @ 14/-/- ₹ 100 - 64/16/- Labor @ 3/-/- = 13/12/-
7	Munglee and Budlon — Valuation — 35.0.0	3 Rooms average 12 x 6. one of Kucha Roof 2 of tile, walls of mud about 7 feet high, in bad order, foundations. 2 walls 12 feet - 12 ft long of Kucha Pukka masonry	216 Sq: feet @ 8/-/- ₹ 100 - 17/4/- Labor @ 2/-/- = 4/5/-

8a

8

8	Mohun Valuation 50„0.0	1 Room 15½ × 7½ of tile roof. Walls of Mud. 10 feet high. in bad order.	120. Sqfeet @ 8/„ fp % - 10/8„ Labor @ 2/„ - 2/12„
9	Bhujjoo Valuation 100„0.0	2 Rooms average 21½ × 6½ of tile roof. Walls of Mud 10 feet high in bad order	279 Sqfeet @ 8/„ fp % - 22/3„ Labor @ 2/„ - 5/8„
10	Runnow Valuation 50„0„0	1 Room 19½ × 7½ of Kucha Roof, and a tile shed 10×6 walls Do — Ditto	201 Sqfeet @ 8/„ fp % - 16/„ Labor @ 2/„ - 4/„
11	Dalee Valuation 50„0.0	1 Room 19 × 7½ of Tile roof and a tile shed 5×4. Walls Ditto — Ditto	137 Sqfeet @ 8/„ fp % - 11/„ Labor @ 2/„ - 2/12„
12	Bheekha Valuation 250„0.0	3 Rooms average 8¾ × 8' One of Kucha roof and the rest of 2 story high foundations of Kucha Pukka masonry, and walls of mud, in good order	277 Sq. feet @ 18/„ fp % - 49/13„ Labor @ 3/„ - 8/4„
13	Monnah And Ghuseetah Valuation 250„0.0	2 Rooms average 12 × 10' one of Kucha roof and the other of tile. also a tile shed 11½ × 7½ walls of mud about 8 feet high in good order	321 Sqfeet @ 8/„ fp % - 25/10„ Labor @ 2/8„ - 8/„
14	Piaree Valuation „ „	2 Rooms average 6¾ × 6½ of tile roof. walls of mud about 9 feet high in fair order.	175 Sqfeet @ 12/„ fp % - 21/„ Labor @ 2/8„ - 4/6„
15	Mohun Valuation 300„0„0	3 Rooms average 7½ × 5½. two of tile roof 2 story high, and one of Kucha roof a tile shed 5¾ × 5½ walls of Kucha Pukka masnry 10 feet high, in bad order.	200 Sqfeet @ 30/„ fp % - 60/„ Labor @ 10/„ - 20/„
16	Buldeo Sohoy Valuation 3,500„0.0	1 Room 25½ × 24½ of Pukka roof. Walls Kucha Pukka Masonry 14 feet high in good order. base pukka	Value 2000/„ Labor - 666/„
17	Woosainee Valuation 60„0„0	4 Rooms average 13½ × 6½ - 3 of Kucha Roof. One of tile and a shed of Jam 8×11' walls of Mud 9 feet high in bad order	337½ Sqfeet @ 8/„ fp % - 26/15„ Labor @ 2/„ - 6/12„

18	Neengun Valuation 50 „ 0 „ 0	2 Rooms average 8½ × 8½. of Kucha roof walls of mud 9 feet high in bad order	1140 Sqft: @ 10 p. ft P° = 11.16 „ Labor @ 2 p. f. = 2/12 p.
19	Bhudee Valuation 3000 „ 0 „ 0	4 Rooms average 21 × 10½ three of Kucha roof one of tile 2 stories high, walls of Kucha Pukka Masonry 12½ feet high in good order	Valuation 1860 „ 0 „ 0 Labor = 500 . 0 . 0 8c
20	Dunoodun Kloss valuation — . „ „	5 Rooms average 17 × 11½ One of Pukka Roof and the rest of tile. 4 walls of One room and 2 of another one of Pukka Kucha Masonry the rest of mud 11 feet high, a second story of Pukka roof walls Pukka kucha 11 feet high in half a room. all in fair order	Valuation = 2100 p. Labor = 710 p. „ .
21	Moonna and Ghusseeta Valuation 1000 „ 0 „ 0	2 Rooms average 21 × 15½ of Kucha roof Walls of Pukka Kucha Masonry 11½ feet high in good order	Valuation = 1143 p. „ Labor = 400 p. „
22	Gungadeen and Budloo Valuation 1000 „ 0 „ 0	5 Rooms average 13 × 8 - 4 of Kucha and one of tile roof in bad order Walls of Pukka Kucha Masonry, but 1 (30 × 5) which is of mud. a tile shed 30¾ × 9¾ height of the rest Walls about 18 feet	Valuation = 260 p. „ Labor = 70 p. „
23	Kishna Sohoy Saligram Valuation 3,000 „ 0 „ 0	1 Room 35½ × 19½ of Pukka Roof, Walls of pukka kucha masonry 11½ feet high. in good order.	Value = 1960 p. „ Labor = 650 p. „
24	Mujlis Roy Valuation 700 „ 0 „ 0	1 Room 35¾ × 21½. 1/3 (a) of grass 2/3 (a) of pukka roof 2 stories high and 2/3 (a) pukka roof only one story high. walls of Kucha Pukka Masonry 15 feet high in good order	Value = 2553 p. „ Labor = 850 p. „
25	Subool Churn Valuation 1,000 „ 0 „ 0	6 Rooms average 13 × 9. 4 of Kucha roof and 2 of tile a wall 23 × 8½ of pukka kucha Masonry, the rest of mud in bad order	700 Sqfeet @ 10 p. „ P° = 280 p. „ Labor = 75 p. „
26	Seetaram Valuation 3,100 „ 0 „ 0	5 Rooms average 15¾ × 13½. two of tile roof 2 story high and the rest of Kucha roof. walls of Pukka kucha. Masonry 11 feet high. in good order. a grass shed 20½ × 5.	Value = 1400 p. „ Labor = 400 p. „

27	Manpie Ram Valuation 9000 „ 0 „ 0	2 Rooms average 28 × 16 of pukka roof. a second story 28' × 11' of Pukka roof 11 feet high. walls of kucha Pukka Masonry 11 feet high base of Stone Slabs, in good order	Value - 2,600 /- /- Labor - 800 /- /-
28	Muslis Roy Valuation 9,500 „ 0 „ 0	3 Rooms average 21½ × 10' One of pukka and one of Grass roof. 2 Story high. the 3rd of pukka roof (1 story) walls of kucha pukka Masonry 12 feet high - base of Stone slabs	Value = 3,000 /- /- Labor = 1,000 /- /-
29	Chainsookh & Bukhsheram	3 Rooms average 20½ × 11½, of pukka roof walls of pukka kucha Masonry, in good order, a grass shed 28½ × 9 3/4' height 15 feet from the side of the Mullah the height is 26½ feet.	Value - 3080 /- /- Labor - 900 /- /-
30	Gianchund & Brandsookh Valuation - 16,000 „ 0 „ 0	15 Rooms average 20 × 10 2/4 of Pukka roof, but one, which is of tile. walls of kucha pukka masonry about 11 feet high, a grass shed 47 3/4 × 8' all in good order.	Value - 4800 /- /- Labor - 1600 /- /- Owners state that they paid 6000 /- /- for the ground alone and 9000 /- /- for their buildings.
31	Khemanund and Dongurshul Valuation - 1,000 „ 0 „ 0	1 tile shed 73½ × 14¼. supported one one side on mud Walls 11½ feet high and on the other (8') pukka kucha pillars 5½ feet high in fair order.	Value - 250 /- /- Labor - 80 /- /-
32	Jowahur Mul Valuation - 13,000 „ 0 „ 0	8 Rooms average 20 × 13' - five of tile roof - 3 of which are 2 story high and the rest of pukka roof - 3 walls of one and 2 of another room are of mud and the rest of pukka kucha - Masonry - high about 13½ feet, a tile shed 50½ × 13' all in bad order.	Value - 3,000 /- /- Labor - 980 /- /-
33	Hunsookh Roy and Ramkunnun Valuation 3,000 „ 0 „ 0	2 Rooms average 28½ × 18½ - 1 of pukka roof and the other of tile one of length wall of a room of mud, the rest of pukka Kucha Masonry about 13½ feet high - in fair order	Value - 1,200 /- /- Labor 400 /- /-

34	Dyakishun Valuation 4000 " 0 " 0	3 Rooms average 21 x 12 - two of kucha roof and the 3rd of tile but in very bad order. Walls of kucha Pukka Masonry but one as in No:33, the rest in good order	Value = 800 /" /- Labor = 225 /" /-
35	Bundeedhur Valuation — " " "	8 Rooms average 11 x 7½' One of pukka and the rest of kucha roofs, walls of kucha pukka masonry, about 12 feet high in bad order. One small dome 4 x 4' on the outside and 12½ feet high of pukka kucha Masonry, and pukka plastered, also a grass shed 15 2/8 x 5'.	Value = 800 /" /- Labor = 225 /" /-
36	Seetaram Valuation 2000 " 0 " 0	3 Rooms average 21 x 9½ of pukka roof one 2 story high - walls of pukka kucha Masonry about 15 feet high in good order.	Value = 1500 /" /- Labor = 500 /" /-
37	Moonna and Chusseeta Valuation 2500 " 0 " 0	9 Rooms average 15½ x 8½ - two of tile roof and one of which is 2 story high and the rest of kucha roof walls of mud 10 feet high but the foundations which are of Pukka masonry as also the back wall of the house 31 x 9½ feet of kucha pukka Masonry. whole in bad order	142.9 Sqfeet @ 8 /" /- P C = 724/8/- Labor = 274 /" /-
38	Chandookh & Bukshyram Valuation — " " "	7 sheds average 25½ x 11½' One of tile and rip of grass in bad order 5 supported on one side on mud walls 8 feet high and on the other of bullies. and 2 on bullies only.	2030 Sqft. @ 8 /" /- P C = 101/3/" Labor 24/8/"
39	Seedulpersaud and Abdoolkureem Valuation — " " "	2 Rooms average 15 x 8½' One of tile and one of grass roof - walls of mud 8 feet high, and a grass shed 17 x 10½' in bad order, part of wall at the Gate about 12½ x 7' and the foundations of that Wall of kucha pukka Masonry.	382 Sqfeet @ 6 /" /- P C = 22/14/" 234 Cubic feet kucha pukka Masonry @ 1/8/" P C = 10/3/" and One Gateway = 15 /" /- Labor = 13 /" /-
40	Jurakhun Val: 500 " 0 " 0	One wall of mud 31 feet long about 6 feet high in bad order	Wall and grass shed 87 /" /-
41	Bijnauth Valuation — " " "	One tile shed and one Room with kucha pukka	Value 800 /" /- Labor 225 /" /- House closed to

41	Nunnamkulsh	One tile shed 10'x10' One one side one mud wall anoth the other of posts.	Value = 5/-/- Labor = 1/-/-
42.	Byjnauth	One tile Shed and one Room with kucha pukka walls 20'x10 3/4'.	Value 200/-/- Labor 60/-/- House close to Gyan Chund's and was first included in the Valuation 500/- agreed on for that house. but as it is a separate property 200/- have been decided to be given to Byjnauth and only 400/- to Gyan Chund.

(Signed) E. W. Hutchinson Lieutt.
Ex. Engineer 6th Division Sylhet

Attending the Committee

(Signed) J. Eliot Lieutt
Temporary Asst to Commd

(Signed) Geo: Sim Lieutt
Offg Ex. Engr 7th Division

(Signed) C. Troup Major President

(Signed) C. Boulton Captain
(Signed) Nasir Ally.
(Signed) C. Warde Lieutenant
(Signed) R. Wroughton Lieutt.
} Members

(Signed) P. Ashburnham Brigadier
Commanding the Station.

Vol. III — 12

APPENDIX

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APPENDIX

GANGES CANAL WORKS.

NORTHERN DIVISION.

By CAPT. A. G. GOODWYN, *Executive Engineer.*

ON BLOCK-SINKING.

The object of this paper, and of the tabular statement which accompanies it, is, the discovery of the law which regulates the expense of block-sinking for foundations, as far as the operations in the bed of the Solani teach.

2. The statement embraces a period of 2 years and 4 months, or from 1st April 1848 to 31st July 1850, and shows the result of block-sinking operations since my connection with the Northern Division Ganges Canal, as far as relates to the Aqueduct Proper, with the exception of sinking 16 wells for the support of the steps at the flanks of the abutments of that work.

3. To render this statement complete, however, similar detail is required regarding the undersinking of the blocks for the support of the curved revetments connecting the work in the bed of the river with that on the banks; and, as these blocks are of uniform size and shape, and both are such as are likely to be more generally adopted in this country than those of many of the very large blocks supporting the heavy weight of the piers and abutments of the Solani Aqueduct, it is much to be desired that a similar record should, hereafter, include them.

4. Again, this statement should embrace the whole of the block-sinking operations in the bed of the Solani, but in it I have not noticed the labors of my predecessor, Lieutenant H. Yule, of Engineers, on account of the monthly progress reports of block-sinking, prior to my receiving charge, showing merely the depth of sinking remaining to be executed for each block. It is true that materials exist for supplying every information that can be desired on this point, Lieutenant Yule's records being most complete and lucid, but as the depths to which blocks were sunk varied greatly, and moreover the sinking of the same blocks was not continuous, the labor of compiling from these records a list which should show each month the progress on each block, with the mean depth at which that progress took place, involves the formation of an entirely new set of progress reports, and is a work greater than I am at present equal to.

5. One great difficulty in framing this statement has been to arrive at the true mean depths at which sinking was performed. This difficulty has beset me at the outset and has not been overcome. As an exemplification of it, suppose, on the first of a month, a block was down 14 feet, and on the last day of the month 20 feet, and that the cost of sinking during the month was 132 Rs. Now, in this case, the rate per running foot would be 22 Rs., the progress being 6 feet; also the mean depth at which sinking was performed was 17 feet. In making my calculations I have used data similarly obtained. But it must not be supposed that the cost of sinking the block from 14 to 17 feet was the same as that from 17 to 20 feet, or that, consequently, as far as the valuation of work goes, 17 feet is the correct mean.

6. In reality, the expense of sinking varies more nearly as the cubic contents of the crater caused by that operation, added to a certain amount of excavation from beneath the crater, or as the cubic contents of a portion of the block taken solid, of the depth sunk, added to some multiple of the cube of that depth sunk, than in any other proportion I am aware of. But what this multiple of the cube of the depth is, can only be ascertained by considering each particular block.

7. For further exemplification, suppose progress as above stated to have occurred on a detached block 20 feet square, the soil to be moved being equal to the content of a crater whose sides run up from the foot of the block everywhere at an angle of 45°.

The cubic content of such a crater would be—

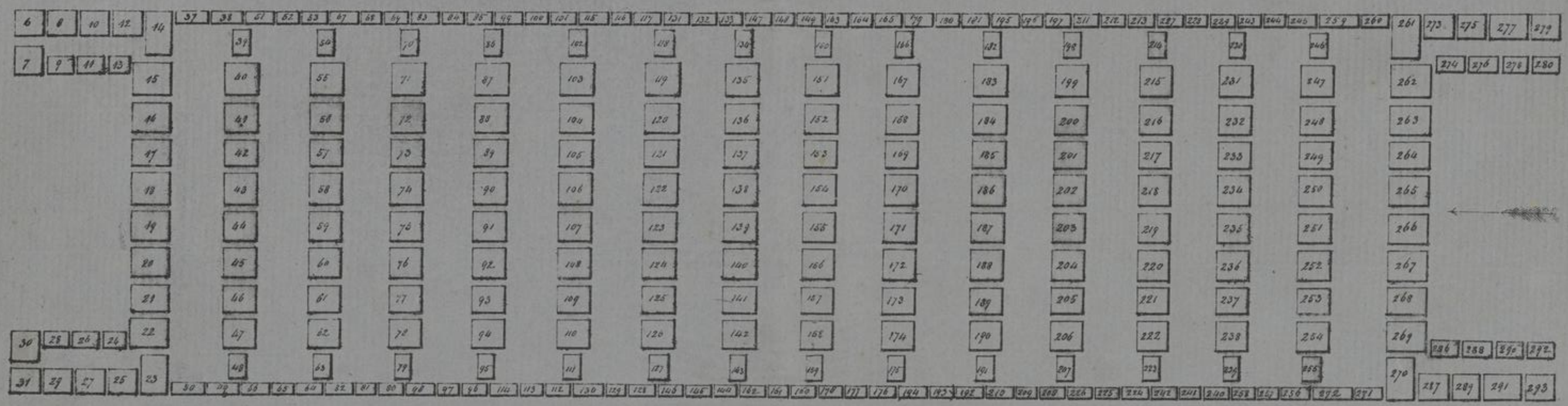
$$\overset{L}{20}\times\ \overset{B}{20}\times\ \overset{D}{20}+\ 4\times\ \overset{L\text{ or }B}{20}\times\ \frac{20^2}{2}+\frac{4}{3}\times\ \overset{D}{20^3}\text{ or}$$

$$20\times\left\{\begin{matrix}\text{area included in}\\ \text{circumference of}\\ \text{base of block.}\end{matrix}\right\}+3\tfrac{1}{3}\times\ 20^3$$

And the work executed on each foot of sinking between 14 and 20 feet would be as follows :

		MODULUS C. F.		RS.	A.	P.
15th foot	$1\times\ 400+\ 3\frac{1}{3}\ (15^3-14^3)=$	$2{,}503\frac{1}{3}$	costing	16	9	5
16th do.	$1\times\ 400+\ 3\frac{1}{3}\ (16^3-15^3)=$	$2{,}803\frac{1}{3}$	do.	18	9	3
17th do.	$1\times\ 400+\ 3\frac{1}{3}\ (17^3-16^3)=$	$3{,}123\frac{1}{3}$	do.	20	11	2
18th do.	$1\times\ 400+\ 3\frac{1}{3}\ (18^3-17^3)=$	$3{,}463\frac{1}{3}$	do.	22	15	2
19th do.	$1\times\ 400+\ 3\frac{1}{3}\ (19^3-18^3)=$	$3{,}823\frac{1}{3}$	do.	25	5	4
20th do.	$1\times\ 400+\ 3\frac{1}{3}\ (20^3-19^3)=$	$4{,}203\frac{1}{3}$	do.	27	13	8
By addition	$6\times\ 400+\ 3\frac{1}{3}\ (20^3-14^3)=$	19,920	do.	132	0	0

FOUNDATION BLOCKS
of the
SOLANI AQUEDUCT.



Scale 90 Feet to an Inch.

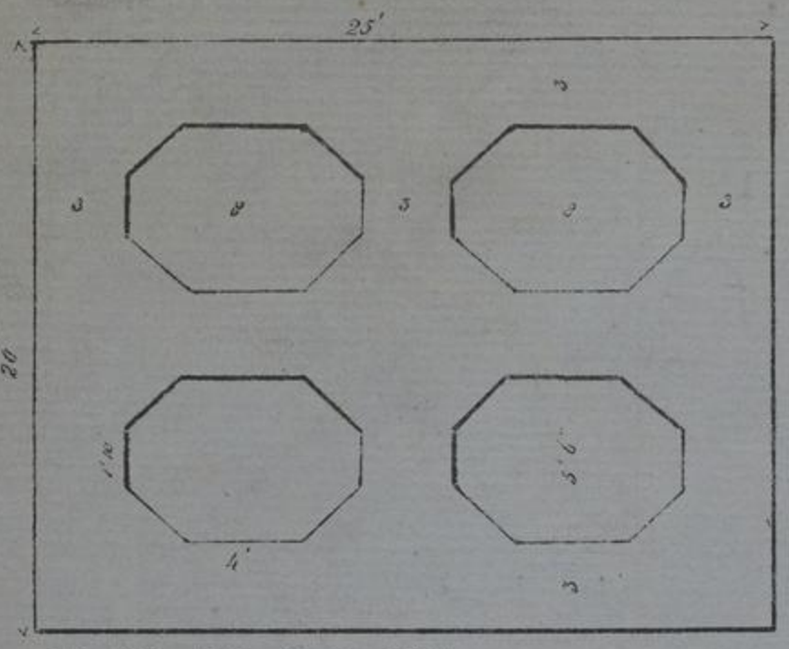
90 80 70 60 50 40 30 20 10 0 90 180 270 feet.

Secundra Orphan Press.

Plan of Blocks Nos 14. 23. 261. 270. Book Plan

Sup.t cont: 353. 4" Octagon Italic

___ d.o ___ 324. 0" Squar



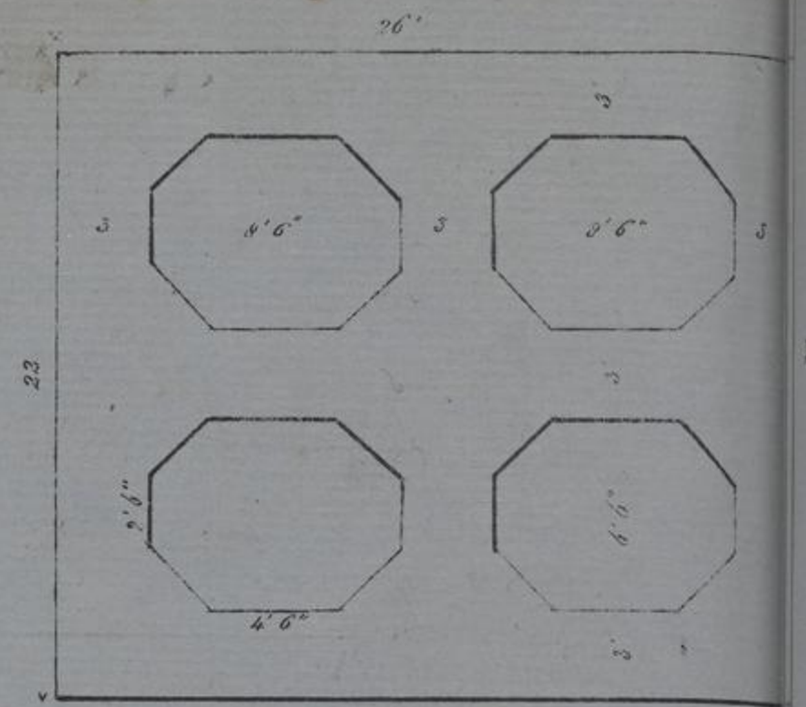
$25 \times 20 - 5 \cdot 5 \times 8 \times 4 = 324$

$25 \times 20 - 5 \cdot 5 \times 8 \times 4 + 1 \cdot 83' \times \frac{2}{3} \times 16 = 353 \cdot 3$

Blocks Nos 15. 16 &ca Total 16

Sup.t cont: 385'. 0" Oct:

___ d.o ___ 351'. 0" Sq:



$26 \times 22 - 6 \cdot 5 \times 8 \cdot 5 \times 4 = 351$

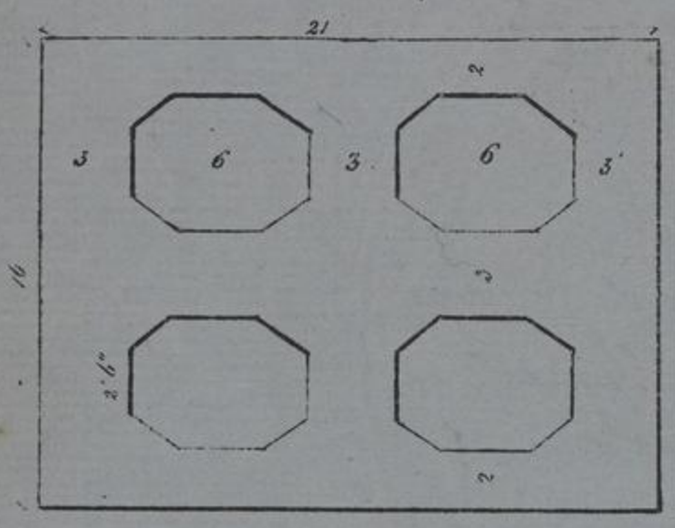
$26 \times 22 - 6 \cdot 5 \times 8 \cdot 5 \times 4 + 2 \times \frac{2}{3} \times 16 = 385$

½ scale

Blocks Nos 8. 10. 12. 8 ca Total 12

Sup.t cont: 240' Oct.

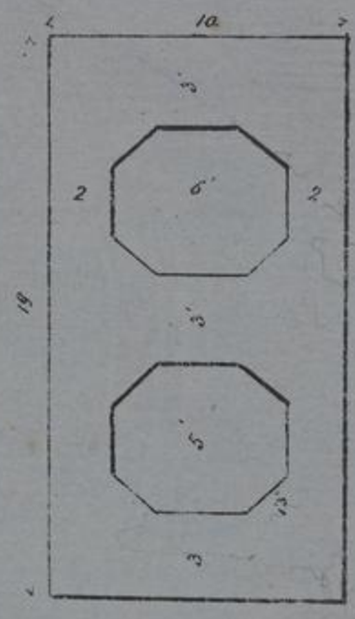
___ d.o ___ 228' Sq:



Blocks Nos 9. 11. 13 &ca Total 6

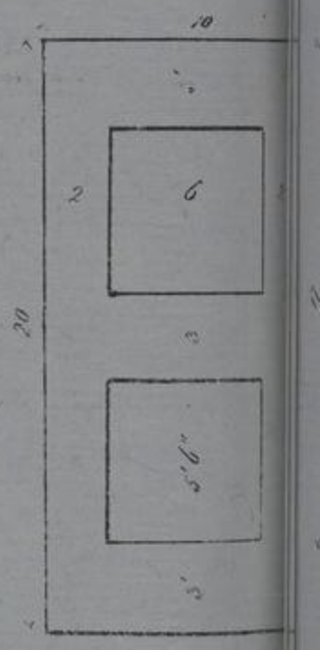
Sup.t cont: 137'. 6 Oct

d.o ___ 130'. 0



Blocks Nos 276. 288. T

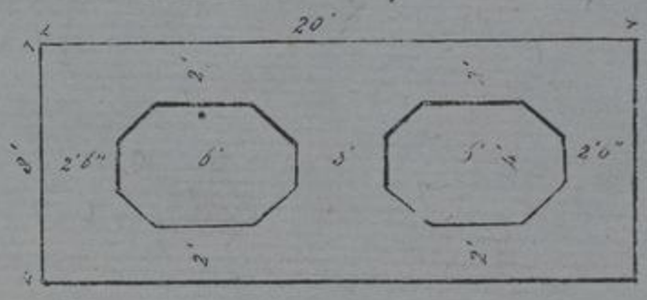
Sup.t cont 134'



Cutwater Blocks Total 28

Sup.t cont: 118'. 0" Oct:

___ d.o ___ 112'. 0. Sq:

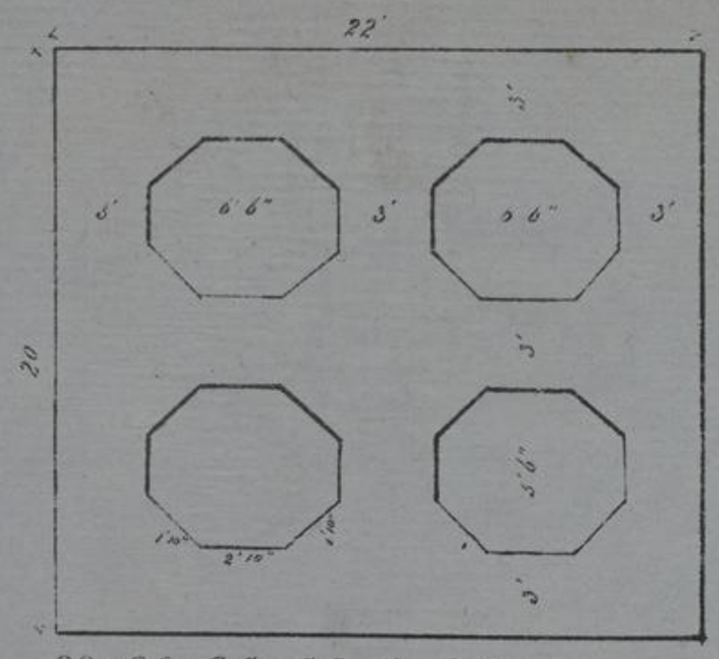


Aqueduct 0

NB. The curtain h
147 and 129 on the n
the aqueduct, respe
their tops only have
are of equable thic
ends are vertica
of 1 in 8.

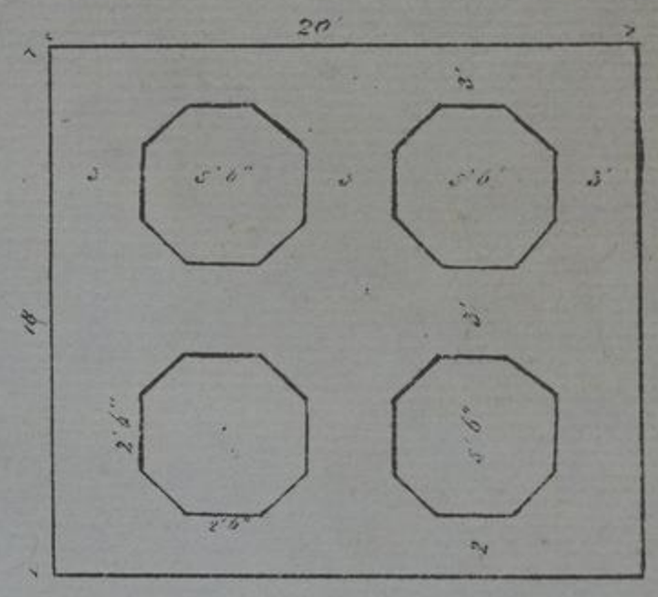
A Porter

Pier Blocks Nos 40. 118 &ca Total 112.
Sup.l cont: 323'. 10½" Oct:
do 297'. 0" Sq:

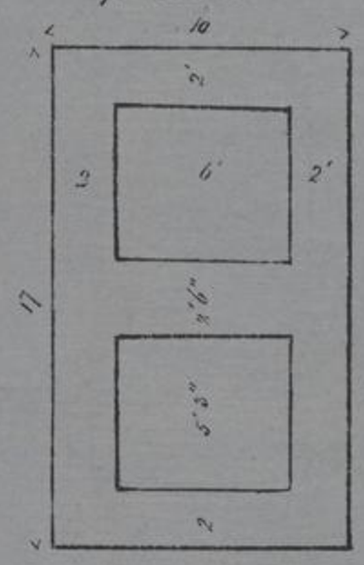


22×20−6·5×5·5×4=297
22×20−6·5×5·5×4+1·83×$\frac{1·83}{2}$×16=323·9

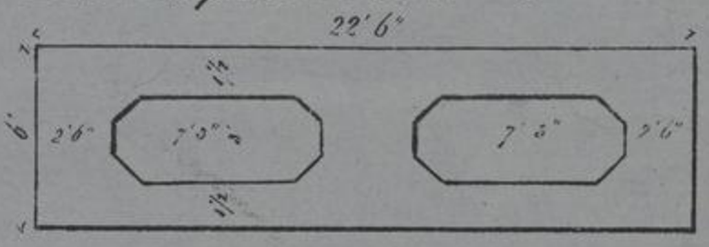
Blocks Nos 6. 7 30 &ca Total 8
Sup.l cont: 257 Oct:
do 239 Sq:



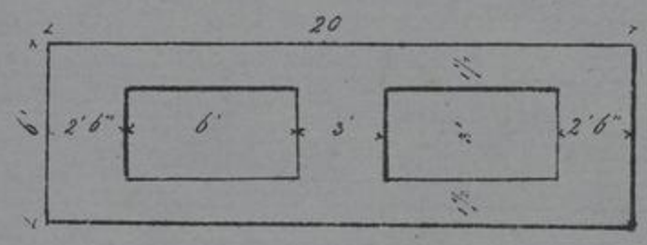
Blocks Nos 274. 278. 286. 290
Total 4
Sup.l cont 107'



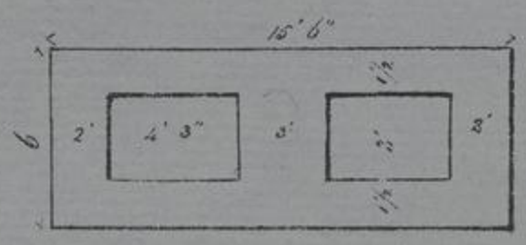
Curtain Blocks Nos 37. 38. 49. 50. 259. 260. 271. 272
Area of Oct portion 93'. 5. Square feet
do Sq: do 91'. 5. do



Curtain Blocks Nos 51. 53. 64. &ca
Sup.l cont 84'. 0"



Curtain Blocks Nos 52. 65. 68. 81 &ca
Area 67. 5

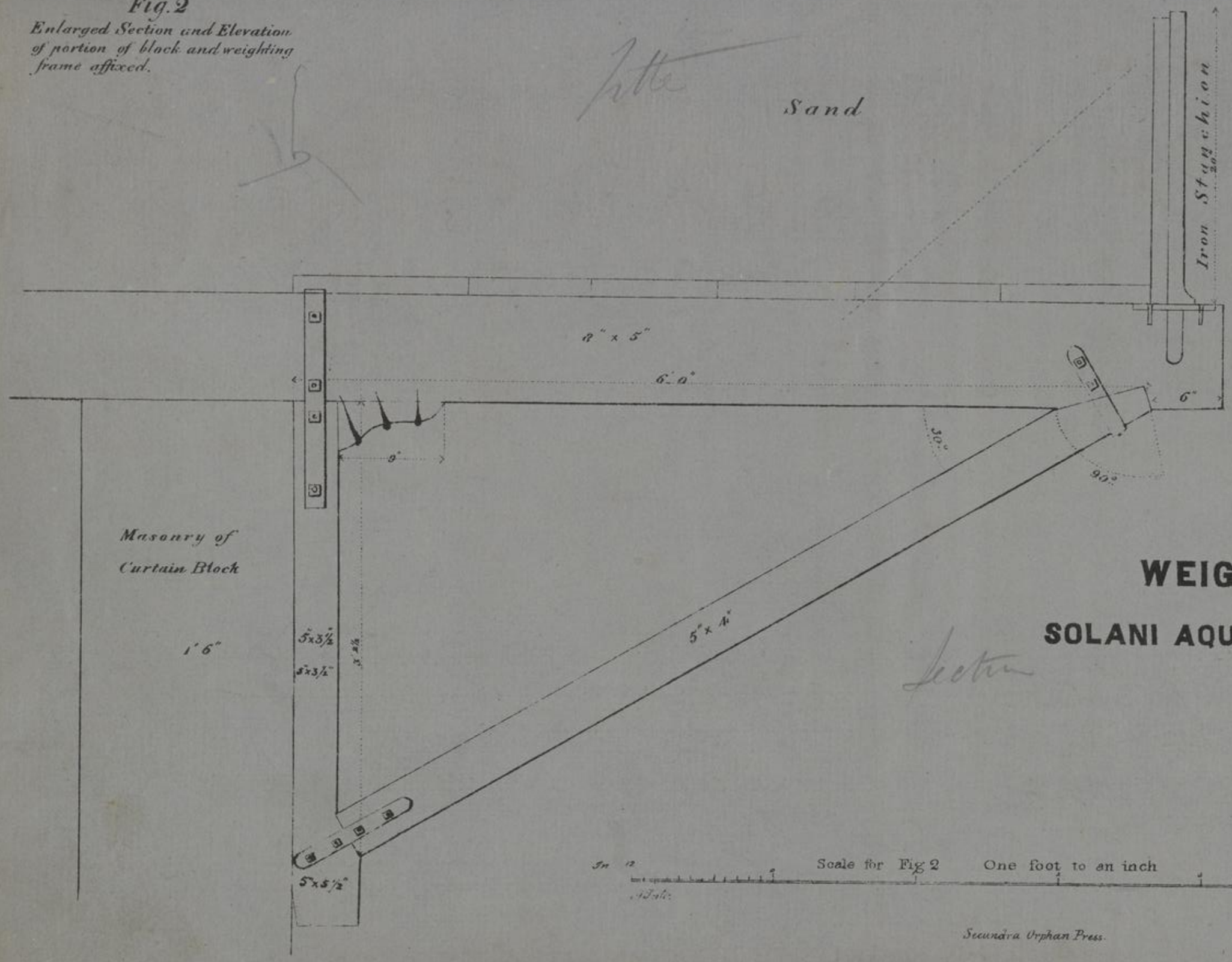


and including Nos
downstream sides of
the left abutment, have
in plan. Their walls
shown, and their
sides have a batter

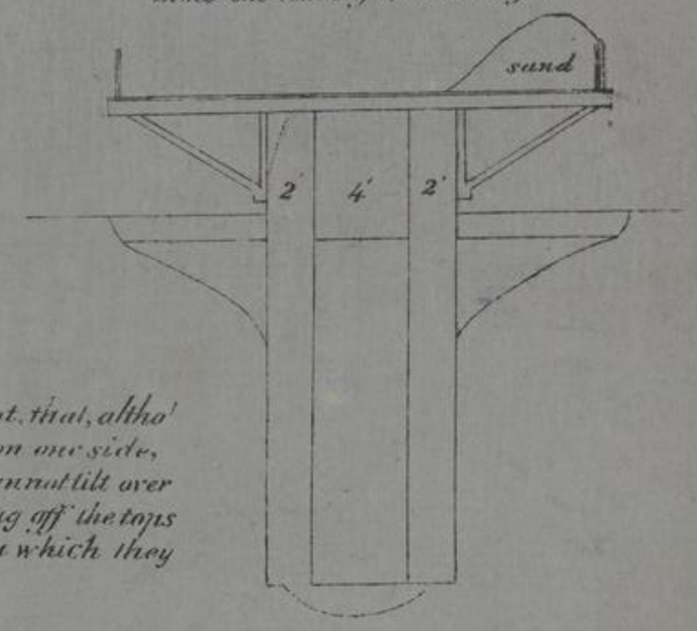
inch

Appendix C

Fig. 2
Enlarged Section and Elevation of portion of block and weighting frame affixed.



Section of Cutwater Block
showing application of weighting frame
Scale one tenth of an inch to a foot



N.B It is evident, that, altho' merely loaded on one side, such frames cannot tilt over without breaking off the tops of the blocks on which they are fixed.

WEIGHTING FRAMES
TO FACILITATE
SOLANI AQUEDUCT BLOCKSINKING

Scale for Fig 2 One foot to an inch

Secundra Orphan Press.

(Sd) A. C. Goodwyn Lieut[t]
Ex Engr N. Divn G. Canal.

The number of cubic feet of the modulus, or supposed quantity of soil displaced, due to each foot of sinking being known, the cost of each foot is calculated, on that number, by simple proportion; the total number of cubic feet of the modulus being found by the expression; $6 \times 400 + 3\frac{1}{3}\ (20^3 - 14^3)$ to be 19,920, and the total expense being known to be Company's Rupees 132.

8. Now from this it appears that the mean depth, as far as expense is concerned, is $17\frac{1}{2}$ feet nearly, instead of 17 feet, and that the lower $2\frac{1}{2}$ feet cost as much as the upper $3\frac{1}{2}$ feet, on the whole monthly progress of the block in question.

9. By some such calculation greater accuracy in the statement of mean depths might undoubtedly have been obtained, but the work would have run out to a length that, with the limited time and means at my disposal, I could not pretend to follow.

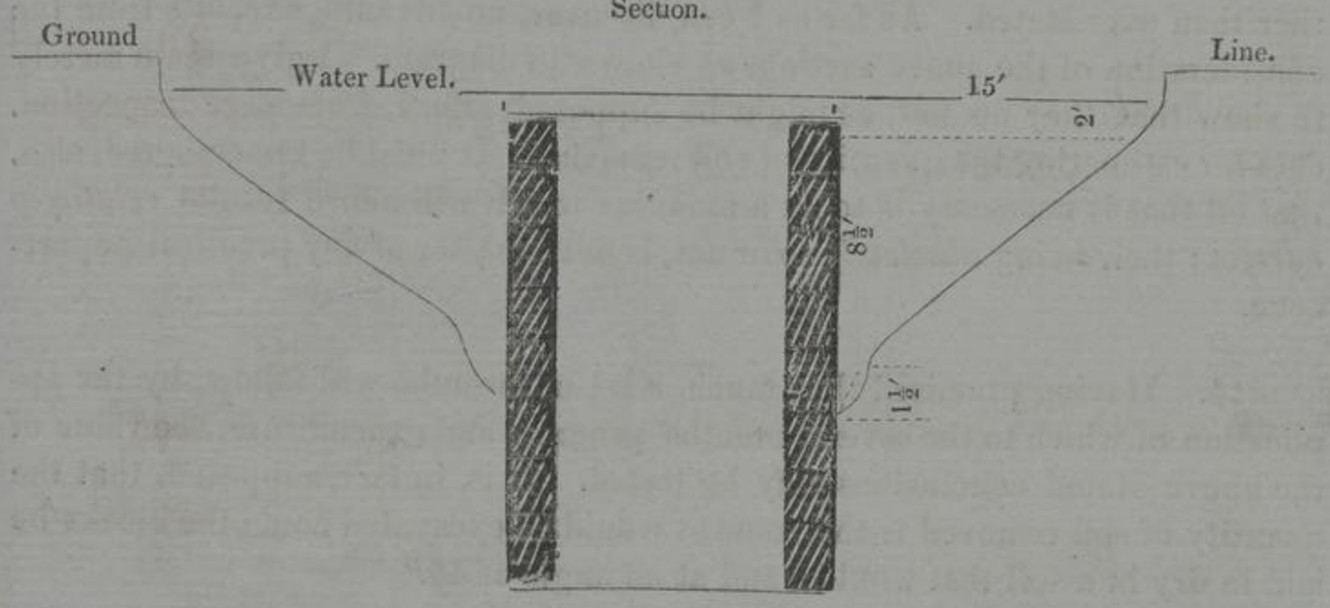
10. The above example is wholly suppositious, and must not be taken as a guide for rates.

11. In the case of heavy blocks, *i. e.* those of 1st, 2nd and 3rd classes, and of the cutwater blocks of the 4th class, the soil has been found at the sides of the craters at a somewhat steeper slope than in that of the long curtain blocks of the 4th class; or rather, I believe, to speak more correctly, in the case of the latter the sand runs down the sides of the craters in a somewhat less steep slope than in the case of the former, owing, as I suppose, to the greater rapidity with which the heavy blocks sink. What I mean to say is, that, in the case of the large blocks, the sand has not time to take the same angle of repose as with the small ones, and consequently the apparent disturbance in the vicinity is less.

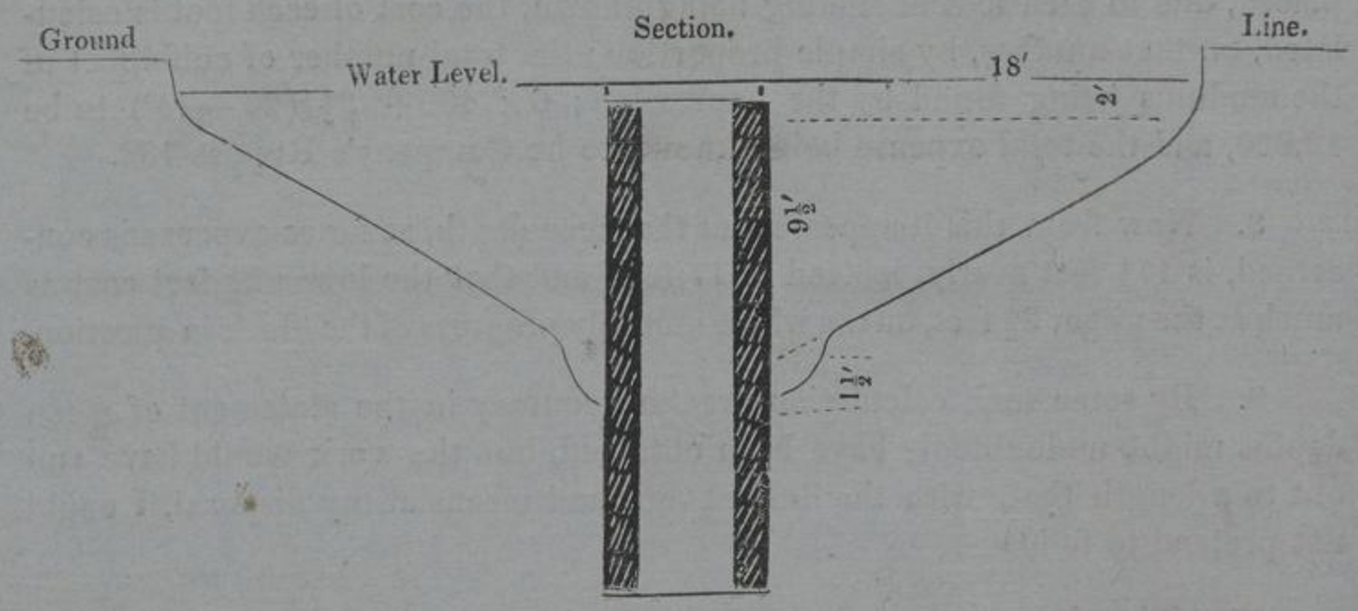
12. The section of these craters of course varies with the proportions of clay and sand in the soil, but the following may be taken as average sections:

1st, 2nd and 3rd Classes,—and 4th Class Cutwater Blocks.

Section.



4th Class Curtain Blocks.



The sectional areas of these craters possibly vary from 220 to 280 square feet, but neither of these amounts adequately represents the true quantity of soil removed in block-sinking; this true quantity, when the circumferences of blocks are the same, varying inversely in some proportion of the weight to the base of the block, although the discovery of what that proportion is, exactly, is still a desideratum.

13. Any one who has watched the bubbling up of springs, throwing up as they do, when first opened, large quantities of the soil through which they pass, will, I think, agree, that in estimating the craters as running from the feet of the blocks upwards at an angle of 45°, too great an allowance would not be made for the quantity of soil to be removed. My calculations, as far as they go, prove this; and unless even greater value is assigned to weight of blocks, in proportion to their bases, than I am disposed to allow, the conclusion appears quite sound that in calculating the soil removed, thus, the results are under rather than over stated. As far as I can discover, no advantage results from the consideration of the above sections as shown in diagram. I give them merely to show that they do not, as might be supposed, afford, from mere inspection, data for estimating the quantity of soil removed. It must be remembered, also, that all that is necessary is to fix a modulus which will afford results *relatively* correct; their being *absolutely* so or not, is not a matter of any practical importance.

14. Having premised thus much, a set of formulæ will follow, by the application of which to the several months' progress and expenditure, the value of the above stated conclusions may be tested. It is, in fact, supposed, that the quantity of soil removed is the same as would be excavated could the blocks be laid in dry in a soil that would stand at an angle of 45.°

The expressions obtained are not the simplest possible algebraically, but are such, as, with the aid of good tables of squares and cubes, will, it is believed, give results with the least possible labor.

Let l be the length in any line of blocks, as a pier, taken up by one block.
b be the breadth of the block.
d „ depth sunk.
s „ space or interval between blocks.
n „ number of blocks.

Thus—

For any number of blocks, of uniform breadth and length in a continuous line, other than the end ones .. } the formula is, $\begin{cases} n\sqrt{(l+s)\,bd+(l+s)\,d^2} \text{ or} \\ n\,(l+s)\,(bd+d^2) \end{cases}$

For end blocks of uniform length and breadth, terminating such continuous lines .. } do. $\begin{cases} n\sqrt{(l+\frac{s}{2})bd+(l+\frac{s}{2})\,d^2+\frac{b}{2}d^2+\frac{2}{3}d^3} \text{ or} \\ n\,(l+\frac{s}{2})\,(bd+d^2)+\frac{b}{2}d^2+\frac{2}{3}d^3 \end{cases}$

For any single detached block } do. $\begin{cases} lbd+ld^2+bd^2+\frac{4}{3}d^3 \text{ or} \\ lbd+(l+b)\,d^2+\frac{4}{3}d^3 \end{cases}$

When the lengths and breadths of blocks in a continuous pier are all uniform, then, for the whole pier including end blocks .. } do. $\begin{cases} (n-2)\,(l+s)(bd+d^2)+2\left\{\sqrt{(l+\frac{s}{2})\,(bd+d^2)+\frac{b}{2}d^2+\frac{2}{3}d^3}\right\} \text{ or} \\ d\left\{\sqrt{n\,(l+s)-s}\,(b+d)+bd+\frac{4}{3}d^2\right\} \end{cases}$

Hence when calculating cost of work at any intermediate stage of progress, if

d represent the greater depth arrived at.
d_1 do. less do. do.

Then—

For any number of blocks of an uniform breadth and length, in a continuous line, other than the end ones ..	the formula is,	$n\,(l+s)\,\sqrt{bd+d^2-(bd_1+bd_1^2)}$
For end blocks of uniform length and breadth terminating such line	do.	$n\left\{\begin{array}{l}(l+\frac{s}{2})\,\sqrt{bd+d^2-(bd_1+bd_1^2)}+\frac{b}{2}d^2+\frac{2}{3}d^3\\ \qquad -(\frac{b}{2}d_1^2+\frac{2}{3}d_1^3)\end{array}\right\}$
For any single detached block ..	do.	$(d-d_1)\,\sqrt{lb+(l+b)(d+d_1)}+\frac{4}{3}(d^3-d_1^3)$
When the lengths and breadths of blocks in a continuous line are all uniform, then, for the whole pier including the end blocks ..	do.	$\left\{\begin{array}{l}\sqrt{n(l+s)-s}\times\sqrt{b(d-d_1)+(d^2-d_1^2)}+b(d^2-d_1^2)+\\ \qquad\frac{4}{3}(d^3-d_1^3)\text{ or}\\ \sqrt{n(l+s)-s}\times(d-d_1)(b+d+d_1)+b(d^2-d_1^2)+\\ \qquad\frac{4}{3}(d^3-d_1^3)\end{array}\right.$

15. It now remains to examine how far this agrees with practice. Certain months have been taken as a test, quite at random, and the rates have been struck on the modulus thus obtained. In the comparison the cost of merely the labor of undersinking has been taken into consideration, as it is obvious that when the total expenditure is not proportionate to the mere cost of labor of undersinking, the causes are foreign to the matter at present under consideration, which is how far this theory is supported by the results obtained from all blocks large or small, and whether it deals satisfactorily with the admitted difference of cost of sinking blocks of varied shape at varying depths.

16. May 1848 is the first month examined. It may be proper to state that the calculations have in all cases been made with the utmost care, (they are not inserted an account of their length,) and that where great differences existed in the mean depths at which sinking was performed, the true quantity of work done has been estimated, as nearly as possible, by dividing the work into small portions, in which the variation in depth was less marked. By the aggregation of the results, obtained from these small portions, totals have been found, on which the rates have been struck. These rates are as follows:

May 1848.

1st class 11·93 annas per 100 c. f. of the modulus.
2nd do. 7·90 do. do. do.
3rd do. 11·80 do. do. do.
4th do. 9·78 do. do. do.

The variation in rate here noticed is considerable, and it now remains to ascertain what causes exist affecting the rate in some classes more than in others.

Firstly—

1st class blocks. $\frac{3187}{6733}$ or 0·473 of the whole number of workmen were employed at night.

2nd do. do. $\frac{2365}{5683}$ or 0·416 do. do. do.

3rd do. do. $\frac{784}{2492}$ or 0·315 do. do. do.

4th do. do. $\frac{767}{1985}$ or 0·386 do. do. do.

This varying proportion of men, employed by night on each class of blocks, *may* be a reason of difference of rate. Lieutenant G. Price, the officer in immediate executive charge of this work, is of opinion that work by night is a saving merely of time, and thinks with me that if possible it should not be resorted to, as being more expensive than work by day only. The difference is not material, however, and I do not assign to this first cause the variation in rate which I seek to explain.*

N.N. 273; Vide.

Secondly—

The effective surplus weight in proportion to the bases of the blocks in their average state of immersion, was—

1st class, 572 lbs. to 1 square foot of area included in circumference of base of block.

2nd do. 507 do. do. do. do.
3rd do. 642 do. do. do. do.
4th do. 552 do. do. do. do.

That the varying proportion of weight to the area of the base has a very material effect on the cost of sinking is beyond dispute, but unfortunately no data exist, by which the ratio of velocity of sinking to weight can be accurately determined.

* These remarks were made merely with reference to defective supervision, and interruptions attendant on work performed at night; but, subsequent to writing them, Lieutenant E. Walker, of the Engineers, drew my attention to the fact of much greater progress being made in sinking a well of his when workmen were employed at considerable intervals than when the work was carried on uninterruptedly. This was corroborated in the case of a well sunk in my own compound. The experiment was then extended to six blocks in the Dhunouri revetment foundations, which were worked at every other day only. The record of the result there, was, however, most unfortunately, vitiated by circumstances which need not be detailed; still every reason exists for believing that the result was the same as in the two former cases. Paradoxical as advocacy of intermitted block-sinking may appear, I strongly recommend its *trial*. Any one who has examined old kutcha wells and has observed in what way the bottoms, only, of the cylinders fall in, will see how intermitted sinking may be recommended by argument as well as by fact. Whether however, the benefits that might accrue from sinking, thus performed, would not be counterbalanced by the extra expense of either moving the block-sinking apparatus, or of making up a double set, is a point that must depend on other circumstances; not the least important of which may be variety of soil to be worked through. A. G. G.

Thirdly—

And this consideration appears the most important of all in the present instance, the height, from whence the jham had to be worked, must be looked to. In the case of the 1st and 3d class blocks, the masonry being 20 feet high, it mattered nothing at what average depth sinking had to be performed, as far as the labor of bringing up any given quantity of earth was concerned. Directly the block was built up from its first height of 12 feet, to its final height of 20 feet, every jham load was raised that height, and the jham-worker had to handle a staff 8 feet longer than before. The time required to work a jham, at the bottom of a block built up to a height of 20 feet, is about one-fourth more than when that block was only 12 feet high. Moreover the jham cannot be forced into the ground so deep as before, and, as the depth of water increases, more and more of the contents of the jham are washed out during its passage upwards; so that the total labor of sinking when the block is 20 feet high, is to the same work when the block is only 12 feet high, as 3 to 2 nearly; or, to speak more correctly, the labor of bringing up any given quantity of soil under these two differing conditions is in this proportion, for it must not be forgotten, that, owing to difference of weight, the *progress*, as before stated, will be greater on any high block, for the same quantity of excavation, than on a low one of the same length and breadth. Now, in the case of the 2nd class blocks, $\frac{264}{672}$ or 0·391 of the work was performed at a height of 12 feet, and, in the 4th class block-sinking, $\frac{64}{479}$ or 0·14 was done under the same circumstances. If then, correction, fairly due on account of different heights, be applied, giving the workmen credit, as it were, for their work valued at the 12 foot standard, the comparative rates on the modulus would be—

1st class blocks		7·95	annas per	100 c. f.
2nd	do.	6·30	do.	do.
3rd	do.	7·90	do.	do.
4th	do.	6·96	do.	do.

It would be easy to show, that, by more accurate calculation of the variation caused by height of blocks, just at the point where the mean depth at which sinking was performed begins to exceed 12 feet, and where the depth of water has not yet materially increased, consequently where the contents of the jham are not materially lessened in their upward passage, these rates would approach each other still more nearly.

17. The next period taken was that of

May 1849.

2nd class blocks 7·97 per 100 c. f. on modulus.

4th do. do (no curtain blocks) } 8·25 do. do.

2nd class $\frac{5,103}{11,761}$ = 0·434 of the workmen were employed at night.

4th class $\frac{646}{1,370}$ =0·471 of the workmen were employed at night.

The effective surplus weight in proportion to the bases of the blocks, in their average state of immersion, was—

2nd class 615 lbs. to 1 sq. foot of area included in circumference of base of block.

4th do. 634 do. do. do. do.

18. These rates agree very nearly with each other; but to render the comparison quite fair, a correction, as before, has to be applied, altho' owing to a different cause; after which they may be placed beside those of May 1848.

19. On 1st December 1848 the number of men to each jham was reduced by Lieutenant Price, from 4 to 3, and on 1st November of the same year the pay of bildars was lowered, by order of the Director of the Works, from 4 Rs. to 3-8 per mensem.

The mistry employed superintending the block-sinking asserts that 3 men work a jham *quite* as well as 4; yet this is neither Lieutenant Price's opinion nor my own, although we agree that they perform *nearly* as much work as four. I have very little doubt that the mistry was influenced in his report by a desire to make it as agreeable as possible. Now—

The pay of a squad consisting of 1 tindal at 6 Rs. per mensem and of 30 bildars at 4 Rs. per mensem, was, before 1st Novr. 1848, .. Co's. Rs. 126

Do. do. when the bildars' pay was reduced to 3-8 per mensem, after 1st Novr. 1848, ... „ „ 111

It appears that a saving of $\frac{15}{126}=\frac{5}{43}$ was made, on labor, by the Director's reduction, and nearly of $\frac{1}{4}$th by Lieutenant Price's reduction; the total saving being $\frac{5}{43}+\frac{1}{4}=\frac{63}{172}=0{\cdot}366$.

20. Therefore the same work which was done before 1st Decr. 1848 for 1 Rupee, was done afterwards for $\frac{109}{172}$ of a rupee.

Consequently the work which in May 1849 cost 7·97 annas, would, in May 1848, have cost 12·57 annas.

21. A reduction on account of the 12-foot standard to which the work for May 1848 was reduced, or—

$\frac{1}{3}\times\frac{539}{778}\times 12{\cdot}57=2{\cdot}90$ annas, must be applied to 2nd class blocks, and the proper reduction to the 4th class blocks also, leaving the results for

2nd class blocks 9·67 per 100 c. f. on modulus.

4th class do. 9·74 do. do.

22. If, instead of taking the mistry's statement of saving of one-fourth, by the reduction of windlass men from 4 to 3, it were taken at one-fifth, which is

probably nearer the truth, the corrected rate on 2nd class sinking would be 8·77 and that on 4th class sinking nearly the same, affording a very close approximation to the reduced rates of May 1848. As it is, however, the agreement is quite as near as could reasonably be expected, and is nearer than I had anticipated when I commenced the investigation.

23. May 1850 has next been taken.

4th class 10·8 annas per 100 c. f. on modulus.

$\frac{1262}{2772} = 0{\cdot}455$ of the whole number of workmen were employed at night.

The weight on the area included in the circumferences of the bases of the blocks is 505 lbs. per sq. foot, in the average state of immersion.

This work would, in May 1848, have cost 17·04 annas per 100 c. f. of modulus, and applying correction of $\frac{1}{3}$ of $\frac{229}{236}$ of 17·04, to effect a reduction to the 12 feet standard of comparison, the rate becomes 11·53 per 100 c. f. of the modulus.

24. For June 1850.

4th class blocks: 11·98 annas per 100 c. f. of modulus.

$\frac{6774}{14340} = 0{\cdot}472$ of the whole number of workmen were employed at night.

In the average state of immersion of the blocks, the weight on the area included in the circumferences of their bases was 613 lbs. to the square foot.

Applying corrections necessary, as before described, the rate becomes—

$\frac{172}{109} \times 11{\cdot}91$, less one-third of this amount, (as all the blocks on which sinking was performed this month were at their full height,) or 12·6 annas per 100 c. f. on modulus.

25. For July 1850.

4th class blocks: 13·62 annas per 100 c. f. of modulus.

No work was done at night.

In the average state of immersion of the blocks, the weight on the area included in the circumferences of their bases was 351 lbs. only per square foot. This small proportional weight is due partly to a rise in the water level, this month.

Applying the corrections necessary, the rate becomes—

$\frac{2}{3}$ of $\frac{172}{109}$ of $13{\cdot}62 = 14{\cdot}33$ annas per 100 c. f. of modulus.

26. The last three rates are for light curtain blocks with splayed bases. They agree well with each other, and appear to point to an error in the formulæ in calculating the section of soil removed, in the case of a line of blocks, at $bd + d^2$, representing a slope of 45° for the craters. It is very desirable that the expression $bd + 3d^2$, representing a slope of rather more than 33° should be tried; perhaps, the results, thus obtained, would be found to agree better with each other than those obtained from the formulæ I have made use of.

27. It appears that, on the Solani works,—

0·135 of a tindal's day's work, or $\frac{1}{222}$ of his month's work, with 4·054 of a bildar's day's work, or $\frac{5}{37}$ of his month's work, is equal to the execution of 100 c. f. of the modulus, including leave on Sundays; but when the proportion of effective weight to the bases of the blocks may be less than that which obtained in the case of the Solani works, the rate on the modulus must be increased in estimating the cost of labor on future works.

28. What has been stated above refers only to the *labor* of undersinking. It is necessary now, however, to see what the total charge on the modulus, including the cost of removing sand from the tops of blocks, of providing tools, and of defraying sundry trifling contingent expenses, attendant on the work, has been.

May 1848.	1st class	23·22	annas per	100 c. f. of the	modulus.	This variation in rates is owing in great measure to the variable distances to which soil was transported.
	2nd do.	17·80	do.	do.	do.	
	3rd do.	21·39	do.	do.	do.	
	4th do.	20·01	do.	do.	do.	
May 1849.	2nd do.	17·80	do.	do.	do.	
	4th do.	17·59	do.	do.	do.	
May 1850.	4th do.	38·35	do.	do.	do.	
June do.	do. do.	25·85	do.	do.	do.	
July do.	do. do.	30·512	do.	do.	do.	

29. Calculating for a large new work I should say that a rate, on the modulus, of 20 annas per 100 c. f. would cover all expenses, out of which the expense of mere labor of undersinking would not exceed 9 annas per 100 c. f.; the remainder of the charge being for materials, such as rope, oil for torches, &c.; cost of removing sand from blocks; percentage for tools, and sundries. A great saving might be effected on the rate of 20 annas per 100 c. f. by the employment of chain, instead of moonge rope. I believe the use of coir rope, even at Roorkee, would have been cheaper than that of moonge.

30. On each block, between every two wells, and on the shore side of that block an earth trough is placed. When operations were first commenced, prior to the earliest date over which this record extends, 10 men were told off daily to the service of this trough, whose duty it was to see that no accumulation of sand took place. This number was soon reduced to 7. On 1st December 1848, when the reduction of men on each windlass from 4 to 3 took place, the number on each trough was reduced to 6, and about 4 months later to 5. The latest distribution for a 4-well block is as follows:

4 windlasses at 3 men each, ...	12
2 earth troughs at 5 each, ...	10
Total,	22

This is the smallest number of men that can work a 4-well block with advantage, according to our latest experience.

31. Very much still remains to be done in determining accurately the relative cost of our block-sinking operations in the bed of the Solani; and I look on this paper merely as one step towards that end, involving as it does a satisfactory explication of the laws which regulate the expense of block-sinking. I have found difficulties in valuing the work start up at every step, in the shape of varying circumstances under which, at different periods, sinking was performed, and, until the true value of these disturbing causes is ascertained, absolutely accurate expressions cannot be entered in the formulæ of calculation. Again, until the formulæ are accurately settled, the effects of disturbing causes cannot be properly measured, and thus these two facts cause the question to vibrate like a balance, and each tends, by degrees, to bring the other to a state of rest.

32. From what has been put forth, it appears, that when it is possible to avoid resorting to blocks with splayed bases, they should never be used, at any rate, if the soil through which sinking has to be performed is sandy. The success of such splayed blocks as regards economy, in a clayey soil, is still doubtful, though I think the balance of probability is against their succeeding as well as perpendicular-sided blocks even here. I do not, of course, allude to a case where a broad base is an especial desideratum. I merely say that the minimum width of a block at top being fixed, if that width admits of a perpendicular-sided block being sunk, and if the same width for the base is reckoned sufficient to ensure the stability of the superstructure, a perpendicular-sided block, as susceptible of being sunk far cheaper than a sloping one, is to be preferred; the difference of cost being calculable by the formulæ given above. But a block, 6 feet wide at top with sloping sides, may undoubtedly be sunk where a perpendicular-sided block of the same width at top will not go down at all; generally owing to its falling over on one side, from unskilful working. However, a line of blocks $8\frac{1}{2}$ feet wide, with perpendicular sides, will be built at the same cost, and sunk cheaper than another of the same length, 6 feet wide at top and 11 feet wide at bottom. In the sloping block, the greater loss of weight, during partial immersion, has something to do with this result.

Blocks might always be advantageously designed in such a way that the weighting frames fixed on narrow ones should be applied with equal facility to wide ones. Three such frames as are used on the Solani Aqueduct block-sinking will bear a weight of 25,000 lbs. with safety; nor, with proper precautions, is there any danger in loading half this weight on one side of a block only.

A. G. GOODWYN, *Lieut.*
Ex. Engineer N. Division Ganges Canal.

Roorkee,
26th August 1851.

Report showing the Progress made, monthly, in sinking each Foundation Block of the Solani Aqueduct Proper, from 1st *April* 1848 *to* 31st *July* 1850.

Roorkee, 26th *August,* 1851.

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class *
1st	April 1848.	22	5·10	2·550	13·005	
		23	9·21	4·605	42·412	
		261	6·75	8·835	59·636	
		262	3·67	10·375	38·076	
		263	0·34	12·040	4·094	
		268	1·00	11·710	11·710	
		269	2·00	11·210	22·420	
		270	8·00	8·210	65·680	
			8)36·07		257·033	7·12
			4·51			
2	2½	2½	4½	4	4½	3½
,,	May 1848.	23	2·43	10·425	25·332	
,,		261	7·62	16·020	122·072	
,,		262	7·95	16·185	128·670	
,,		263	7·66	16·040	122·866	
,,		264	7·96	16·10	128·156	
,,		265	7·41	15·995	118·523	
,,		266	5·79	14·935	86·473	
,,		267	7·70	16·060	123·662	
,,		268	8·20	16·310	133·742	
,,		269	7·20	15·810	113·832	
,,		270	9·87	17·145	169·220	
			11)79·79		1,272·548	15·948
			7·25			
,,	June 1848.	15	0·54	13·01	7·025	
,,		16	0·20	12·84	2·568	
,,		17	0·21	13·005	2·731	
,,		18	0·38	12·34	4·689	
,,		19	5·84	9·94	58·049	
,,		20	7·41	9·985	73·988	
,,		21	7·39	7·165	52·949	
,,		22	6·68	8·44	56·379	
,,		261	2·25	20·955	47·149	
,,		262	1·92	21·12	40·550	
,,		263	2·21	20·975	46·354	
,,		264	2·00	21·08	42·160	
,,		265	2·38	20·89	49·718	
,,		266	4·25	19·955	84·808	
,,		267	2·17	20·995	45·559	
,,		268	1·67	21·245	35·479	
,,		269	2·67	20·695	55 255	
,,			17)50·17		705·410	14·060
			2·95			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
1st.	July 1848.	14	0·82	13·480	11·053	
,,		15	8·58	17·570	150·750	
,,		16	7·71	16·795	129·489	
,,		17	7·20	16·710	120·312	
,,		18	7·53	16·295	122·701	
,,		19	6·28	16·00	100·480	
,,		20	4·62	16·00	73·920	
,,		21	2·62	12·17	31·885	
,,		22	2·36	12·96	30·585	
,,		23	0·17	11·725	1·993	
			10)47·89		773·168	16·144
2	2½	2½	4½	4	4½	3½
,,	August 1848.	14	4·62	16·20	74·844	
,,		16	1·21	21·305	25·779	
,,		17	0·95	20·785	19·745	
,,		18	1·08	20·60	22·248	
,,		19	1·12	19·70	22·064	
,,		20	2·08	19·35	40·248	
,,		21	5·24	16·10	84·364	
,,		22	6·41	17·345	111·181	
,,		23	5·58	14·60	81·468	
			9)28·29		481·941	17·035
			3·14			
,,	September 1848.	14	1·08	19·05	20·574	
,,		17	0·60	21·56	12·936	
,,		18	0·72	21·50	15·480	
,,		19	1·60	21·06	33·696	
,,		20	1·47	21·125	31·053	
,,		21	3·14	20·29	63·710	
,,		22	1·31	21·205	27·778	
,,		23	4·47	19·625	87·723	
			8)14·39		292·950	20·358
			1·80			
,,	October 1848.	14	2·27	20·72	47·054	20·720

* Obtained by dividing the sum of the products, in the 6th column, by the sum of the depths sunk, exhibited in the 4th column thus, $\frac{257\cdot033}{36\cdot07} = 7\cdot12$

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
2nd	April 1848.	7	0·29	21·715	6·297	
,,		30	11·90	5·95	70·805	
,,		31	11·28	5·64	63·619	
,,		103	6·50	15·03	97·695	
,,		104	4·98	15·56	77·489	
,,		106	4·49	15·275	68·585	
,,		107	6·04	14·92	90·117	
,,		108	4·48	14·64	65·587	
,,		109	3·17	14·775	46·837	
,,		110	4·71	14·255	67·141	
,,		279	12·21	6·155	75·152	
,,		280	12·21	6·155	75·152	
,,		292	12·21	6·155	75·153	
,,		293	12·21	6·155	75·153	
			14)106·68		954·782	8·95
			7·62			
,,	May 1848.	30	1·86	12·83	23·864	
,,		31	2·07	12·315	25·492	
,,		103	1·00	18·45	18·450	
,,		104	2·11	18·775	39·615	
,,		105	0·17	13·995	2·379	
,,		106	1·64	18·01	29·536	
,,		107	1·30	18·26	23·738	
,,		108	0·95	17·025	16·174	
,,		109	1·05	16·555	17·383	
,,		110	0·88	16·72	14·714	
,,		215	14·00	7·00	98·000	
,,		216	12·67	6·335	80·264	
,,		217	13·92	6·96	96·883	
,,		218	12·42	6·21	77·128	
,,		219	12·67	6·335	80·264	
,,		220	12·67	6·335	80·264	
,,		221	12·58	6·29	79·128	
,,		222	12·93	6·465	83·592	
,,		279	7·87	16·145	127·261	
,,		280	7·04	15·73	110·739	
,,		292	7·79	16·105	125·458	
,,		293	8·24	16·33	134·559	
			22)147·83		1,384·885	9·36
			6·72			
,,	June 1848.	103	1·83	19·865	36·353	
,,		104	2·03	20·795	42·214	
,,		105	6·82	17·49	119·282	
,,		106	2·43	20·045	48·709	
,,		107	2·37	20·095	47·625	
,,		108	3·82	19·41	74·146	
,,		109	3·32	18·74	62·217	
,,		110	1·78	18·05	32·129	
,,		215	7·50	17·75	133·125	
,,		216	8·83	17·085	150·860	
,,		217	7·58	17·71	134·242	
,,		218	9·08	16·96	153·997	
2nd	June 1848.	219	8·83	17·085	150·861	
,,		220	8·83	17·085	150·861	
,,		221	8·92	17·04	151·997	
,,		222	8·57	17·215	147·532	
,,		279	2·00	21·08	42·160	
,,		280	2·83	20·665	58·482	
,,		292	2·08	21·04	43·763	
,,		293	1·63	21·265	34·662	
			20)101·08		1,815·217	17·95
			5·05			
,,	July 1848.	30	3·89	15·705	61·092	
,,		31	3·30	15·00	49·500	
,,		87	——	——	——	
,,		88	——	——	——	
,,		89	——	——	——	
,,		90	——	——	——	
,,		91	——	——	——	
,,		92	——	——	——	
,,		93	——	——	——	
,,		94	——	——	——	
,,		103	1·08	21·32	23·026	
,,		105	0·96	21·38	20·525	
,,		106	0·60	21·56	12·936	
,,		107	0·49	21·525	10·547	
,,		108	0·54	21·59	11·659	
,,		109	1·24	21·02	26·065	
,,		110	2·92	20·40	59·568	
			9)15·02		274·918	18·300
			1·67			
,,	August 1848.	30	2·07	17·685	36·608	
,,		31	4·90	19·100	95·590	
			2)6·97		132·198	18·960
			3·48			
,,	September 1848.	30	2·14	20·79	44·491	
,,		31	0·31	21·705	6·728	
,,		87	11·07	5·535	61·272	
,,		88	11·07	5·535	61·272	
,,		89	11·07	5·535	61·272	
,,		90	9·00	4·500	40·500	
,,		91	8·50	4·250	36·125	
,,		92	8·50	4·250	36·125	
,,		93	8·50	4·250	36·125	
,,		94	4·75	2·375	11·281	
			10)74·91		395·191	5·27
			7·49			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed on whole class.
2nd	October 1848.	90	2·07	10·035	20·772	
,,		91	2·57	9·785	26·947	
,,		92	2·57	9·785	26·947	
,,		93	2·57	9·785	26·947	
,,		94	6·32	7·91	49.991	
			5)16·10		151·604	9·42
			3·22			
,,	November 1848.	87	3·53	12·835	45·307	
,,		88	2·03	12·085	24·532	
,,		89	2·28	12·21	27·839	
,,		90	1·45	11·795	17·103	
			4)9·29		114·781	12·36
			2·32			
,,	December 1848.	87	4·02	16·61	66·772	
,,		88	5·65	15·925	89·976	
,,		89	5·02	15·86	79·617	
,,		90	5·35	15·195	81·293	
,,		91	6·05	14·095	85·275	
,,		92	4·88	13·51	65·929	
			6)30·97		468·862	15·14
			5·16			
,,	January 1849.	87	1·22	19·23	23·461	
,,		88	1·57	19·535	30·670	
,,		89	1·95	19·345	37·723	
,,		90	1·89	18·815	35·560	
,,		91	2·35	18·295	42·993	
,,		92	2·52	17·21	43·370	
,,		93	5·98	14·06	84·079	
,,		94	4·98	13·56	67·529	
			8)22·46		365·385	16·27
			2·81			
,,	February 1849.	87	0·48	20·08	9·638	
,,		90	0·56	20·04	11·222	
,,		91	0·13	19·575	2·240	
,,		92	1·25	19·145	23·931	
,,		93	2·12	18·26	44.189	
,,		94	4·27	18·185	77·650	
,,		199	9·18	4·59	42·136	
,,		200	9·93	4·965	49·302	
,,		201	9·18	4·59	42·136	
,,		202	9·85	4·925	48·511	
,,		203	10·60	5·3	56·180	
,,		204	10·60	5·3	56·180	
,,		205	10·76	5·38	57·889	
,,		206	9·76	4·88	47·629	
			14)88·97		568·833	6·39
			6·35			
2nd	March 1849.	91	0·62	19·91	12·344	
,,		92	0·50	19·97	9·985	
,,		93	0·33	19·635	6·480	
,,		183	11·43	5·715	65·322	
,,		184	12·59	6·295	79·254	
,,		185	11·18	5·59	62·496	
,,		186	12·59	6·295	79·254	
,,		187	12·59	6·295	79·254	
,,		188	12·59	6·295	79·254	
,,		189	12·57	6·285	79·002	
,,		190	12·57	6·285	79·002	
,,		199	2·92	10·64	31·069	
,,		200	2·34	11·7	27·378	
,,		201	3·17	10·765	34·125	
,,		202	2·46	11·08	27·257	
,,		203	1·75	11·475	20·081	
,,		204	1·79	11·495	20·576	
,,		205	1·63	11·575	18·867	
,,		206	2·56	11·04	28·262	
			19)118·18		838·262	7·090
			6·22			
,,	April 1849.	126	1·65	16·975	28·009	
,,		183	1·36	12·11	16·470	
,,		185	1·61	12·035	19·376	
,,		199	7·37	15·785	116·335	
,,		200	5·95	15·245	90·708	
,,		201	5·77	15·235	87·906	
,,		202	6·75	15·685	105·874	
,,		203	8·04	16·37	131·615	
,,		204	6·50	15·64	101.660	
,,		205	7·04	15·91	112·006	
,,		206	6·21	15·455	95·975	
,,		231	14·03	7·015	98·420	
,,		232	14·03	7·015	98·420	
,,		233	14·03	7·015	98·420	
,,		234	14·03	7·015	98·420	
,,		235	14·03	7·015	98·429	
,,		236	14·03	7·015	98·420	
,,		237	14·03	7·015	98·420	
,,		238	14·03	7·015	98·420	
,,			19)170·49		1,693·294	9·930
			8·97			
,,	May 1849.	126	1·73	19·665	34·020	
,,		183	8·47	17·035	144·286	
,,		184	8·67	16·925	146·740	
,,		185	8·47	17·035	144·286	
,,		186	8·67	16·925	146·740	
,,		187	8 67	16·925	146·740	
,,		188	7·57	16·375	123·959	
,,		189	8·26	16·7	137·942	
,,		190	7·24	16·19	117·216	
,,		199	1·67	20.305	33·909	

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
2nd		200	2·92	20·68	60·386	
,,		201	3·02	19·63	59·283	
,,		202	2·08	20·1	41·808	
,,		203	0·75	20·765	15·574	
,,		204	2·25	20·015	45·034	
,,		205	1·71	20·285	34·687	
,,		206	2·58	19·85	51·213	
,,		231	7·37	17·715	130·560	
,,		232	7·37	17·715	130·560	
,,		233	7·19	17·625	126·724	
,,		234	7·37	17·715	130·560	
,,		235	7·37	17·715	130·560	
,,		236	7·37	17·715	130·560	
,,	May 1849.	237	7·37	17·715	130·560	
,,		238	7·37	17·715	130·560	
,,		247	13·94	6·97	97·162	
,,		248	14·11	7·055	99·546	
,,		249	14·18	7·09	100·536	
,,		250	14·39	7·195	103·536	
,,		251	14·32	7·16	102·531	
,,		252	14·24	7·12	101·389	
,,		253	14·20	7·1	100·820	
,,		254	13·69	6·845	93·708	
			33)256·58		3,322·695	13·00
			7·78			
,,		126	0·47	20·765	9·760	
,,		188	1·10	20·710	22·781	
,,		189	0·43	21·045	9·049	
,,		190	1·45	20·535	29·776	
,,		233	0·18	21·310	3·836	
,,		247	7·33	17·605	129·045	
,,	June 1849.	248	7·16	17·690	126·660	
,,		249	7·09	17·725	125·670	
,,		250	6·88	17·830	122·670	
,,		251	6·95	17·795	123·675	
,,		252	7·03	17·755	124·818	
,,		253	7·07	17·735	125·400	
,,		254	7·58	17·48	132·498	
			13)60·72		1085·638	17·88
			4·67			
3rd		25	11·40	5·70	64·980	
,,		27	11·58	5·79	67·048	
,,		29	10·53	5·265	55·440	
,,	April 1848.	273	9·00	7·71	69·390	
,,		275	8·75	7·835	68·556	
,,		277	12·21	6·155	75·152	
,,		287	9·92	7·25	71·920	
,,		289	9·50	7·46	70·870	
,,		291	12·21	6·155	75·152	
			9)95·10		618·508	6·50
			10·57			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
3rd		25	1·67	12·235	20·442	
,,		27	1·75	11·455	20·046	
,,		29	2·89	11·975	34·607	
,,		273	7·70	16·04	123·508	
,,		275	6·62	15·52	102·742	
,,		277	2·62	13·52	35·422	
,,		287	6·95	15·685	109·011	
,,		289	9·87	17·145	169·221	
,,	May 1848.	291	4·95	14·695	72·740	
			9)45·02		687·739	15·28
			5·00			
,,		12	0·12	12·88	1·545	
,,		273	2·17	20·995	45·559	
,,		275	3·25	20·455	66·479	
,,		277	7·25	18·455	133·799	
,,		287	2·92	20·62	60·210	
,,	June 1848.	291	4·92	19·62	96·530	
			6)20·63		404·122	19·58
			3·44			
,,		12	8·92	17·40	155·208	
,,		25	1·74	13·94	24·256	
,,		27	6·06	16·39	99·323	
,,	July 1848.	29	5·87	16·355	96·004	
			4)22·59		374·791	16·59
			5·65			
,,		25	7·05	18·335	129·262	
,,		27	2·47	20·625	50·944	
,,		29	2·57	20·575	52·878	
	August 1848.		3)12·09		233·084	19·28
			4·03			
4th		9	0·46	21·63	9·950	
,,		24	10·41	5·205	54·184	
,,		26	10·37	5·185	53·768	
,,		28	9·58	4·79	45·888	
,,		70	5·33	14·085	75·073	
,,		102	3·62	12·85	46·517	
,,		111	6·41	11·625	74·516	
,,	April 1848.	274	3·84	10·29	39·514	
,,		276	7·42	8·50	63·070	
,,		278	8·75	7·835	68·556	
,,		286	3·09	11·415	35·272	
,,		288	6·50	8·96	58·240	
,,		290	9·75	7·335	71·516	
			13)85·53		696·064	8·14
			6·579			

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Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
4th	May 1848.	24	2·88	11·85	33·128	
,,		26	2·97	11·855	34·209	
,,		28	3·45	11·305	39·002	
,,		70	3·58	18·54	66·373	
,,		102	0·56	14·94	8·367	
,,		111	0·30	14·98	4·494	
,,		214	14·25	7·125	101·531	
,,		223	14·92	7·46	111·303	
,,		274	5·54	14·98	82·989	
,,		276	0·87	12·645	11·001	
,,		278	0·37	12·395	4·586	
,,		286	7·37	15·895	117·146	
,,		288	5·87	15·145	88·901	
,,		290	4·12	14·27	58·793	
			14)67·05		761·823	11·36
			4·79			
,,	June 1848.	11	0·80	18·88	15·004	
,,		13	3·04	14·26	43·351	
,,		102	2·07	17·785	36·815	
,,		111	4·28	18·80	80·464	
,,		214	7·25	17·875	129·594	
,,		223	6·58	18·21	119·822	
,,		274	4·33	19·915	75·332	
,,		276	9·00	17·58	158·220	
,,		278	9·50	17·33	164·635	
,,		286	2·50	20·83	52·075	
,,		288	4·00	20·08	80·320	
,,		290	5·75	19·205	110·429	
			12)59·10		1,066·061	18·04
			4·925			
,,	July 1848.	11	2·58	20·57	53·071	
,,		13	6·08	18·82	114·426	
,,		24	4·77	15·675	74·770	
,,		26	5·47	16·075	87·930	
,,		28	5·62	15·84	89·021	
,,		37	2·55	1·275	3·251	
,,		38	2·67	1·335	3·564	
,,		51	2·65	1·325	3·411	
,,		52	1·43	0·715	1·022	
,,		53	0·72	0·36	0·259	
,,		54	0·70	0·35	0·245	
,,		63	11·60	5·80	67·280	
,,		67	0·78	0·39	0·304	
,,		68	1·55	0·775	1·201	
,,		79	8·92	16·40	146·288	
,,		102	2·80	20·22	56·616	
,,		111	0·92	21·40	19·688	
			17)61·81		722·347	11·69
			3·64			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
4th	August 1848.	24	2·91	19·515	56·789	
,,		26	3·05	20·335	62·022	
,,		28	3·21	20·255	65·018	
,,		37	9·79	7·445	72·886	
,,		38	8·01	6·675	53·467	
,,		51	6·61	5·955	39·362	
,,		52	8·50	5·68	48·280	
,,		53	6·54	3·99	26·095	
,,		54	5·31	3·355	17·815	
,,		67	6·56	4·06	26·633	
,,		68	5·13	4·115	21·110	
,,		69	6·26	3·13	19·594	
,,		83	6·47	3·235	20·930	
,,		84	4·59	2·295	10·534	
,,		85	3·85	1·925	7·411	
,,		99	3·93	1·965	7·722	
,,		100	6·32	3·16	19·971	
			17)97·04		575·639	5·93
			5·71			
,,	September 1848.	24	0·89	21·415	19·059	
,,		37	3·19	13·935	44·453	
,,		38	1·75	11·555	20·221	
,,		49	7·00	3·500	24·500	
,,		51	4·77	11·645	55·547	
,,		52	3·58	11·720	41·957	
,,		53	6·02	10·270	61·825	
,,		54	4·77	8·395	40·044	
,,		64	5·50	2·750	15·125	
,,		65	6·00	3·000	18·000	
,,		66	7·00	3·500	24·500	
,,		67	5·11	9·895	50·563	
,,		80	8·00	4·000	32·000	
,,		81	7·68	3·840	29·491	
,,		82	5·33	2·665	14·204	
,,		83	0·75	6·845	5·134	
,,		86	10·16	5·080	51·613	
,,		95	9·00	4·500	40·500	
,,		96	8 10	4·050	32·805	
,,		97	7·68	3·840	29·491	
,,		98	8·39	4·195	35·196	
,,		99	0·75	4·305	3·229	
,,		102	0·16	21·270	3·403	
,,		112	8·00	4·000	32·000	
,,		113	8·00	4·000	32·000	
,,		114	8·00	4·000	32·000	
,,		130	8·00	4·000	32·000	
			27)153·58		820·860	5·34
			5·69			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
4th	October 1848.	37	1·08	16·07	17·356	
,,		49	1·30	7·65	9·945	
,,		50	2·16	10·80	23·328	
,,		51	3·08	15·57	47·956	
,,		52	5·60	16·31	91·336	
,,		53	2·58	14·67	37·848	
,,		54	3·50	12·50	43·750	
,,		64	3·18	7·09	22·546	
,,		65	2·43	7·215	17·532	
,,		66	1·43	7·715	11·032	
,,		67	3·16	14·03	44·335	
,,		68	6·31	9·835	62·059	
,,		69	3·60	8·06	29·016	
,,		80	1·68	8·84	14·851	
,,		81	1·50	8·43	12·645	
,,		82	3·10	6·88	21·328	
,,		84	8·69	8·935	77·645	
,,		85	3·18	5·44	17·300	
,,		86	0·87	10·595	9·217	
,,		95	2·20	10·100	22·220	
,,		96	0·50	8·35	4·175	
,,		97	0·75	8·055	6·041	
,,		98	1·16	8·97	10·405	
,,		99	0·72	5·04	3·629	
,,		100	1·88	7·26	13·649	
,,		102	0·51	21·605	11·018	
			26)66·15		682·162	10·31
			2·54			
,,	November 1848.	37	1·24	17·23	21·365	
,,		49	2·94	9·77	26·924	
,,		50	7·59	5·955	45·198	
,,		51	3·29	18·755	61·704	
,,		52	1·29	19·755	25·484	
,,		54	6·12	17·34	106·121	
,,		65	3·54	10·2	36·108	
,,		66	2·32	9·59	22·249	
,,		68	2·86	14·42	41·241	
,,		69	6·07	12·895	78·272	
,,		81	0·98	9·670	9·477	
,,		82	0·81	8·835	7·156	
,,		85	5·31	9·685	51·427	
,,		86	3·57	12·815	45·750	
,,		99	6·20	8·500	52·100	
,,		100	3·31	9·855	32·620	
,,		63	1·42	12·31	17·480	
			17)58·86		680·676	11·56
			3·46			
4th	December 1848.	37	0·60	18·15	10·890	
,,		49	3·27	15·875	51·911	
,,		50	2·68	11·09	29·721	
,,		65	3·71	13·825	51·291	
,,		66	4·10	12·8	52·480	
,,		69	0·85	17·355	14·752	
,,		81	5·52	12·92	71·318	
,,		83	0·81	7·625	6·176	
,,		84	1·50	14·03	21·045	
,,		85	2·94	13·81	40·601	
,,		86	1·60	15·4	24·640	
,,		99	0·10	11·65	1·165	
			12)27·68		375·990	13·59
			2·31			
,,	January 1849.	37	1·10	19·0	20·900	
,,		49	0·44	14·73	6·481	
,,		50	2·27	13·565	30·792	
,,		53	1·27	16·505	20·961	
,,		64	5·44	11·4	62·016	
,,		66	0·35	15·025	5·259	
,,		67	1·52	16·37	24·882	
,,		68	1·54	16·62	25·595	
,,		69	1·23	17·395	21·396	
,,		80	2·44	10·9	2·260	
,,		82	4·63	11·555	53·500	
,,		83	6·44	11·25	72·450	
,,		84	1·44	15·5	22·320	
,,		85	3·02	16·79	50·706	
,,		86	0·61	16·505	10·068	
,,		95	1·35	11·875	16·031	
,,		96	1·19	9·195	10·942	
,,		97	1·52	9·19	13·969	
,,		98	0·99	10·045	9·945	
,,		99	2·93	13·165	38·573	
,,		101	5·72	2·86	16·359	
,,		112	0·95	8·475	8·051	
,,		114	0·20	8·1	1·620	
,,		115	5·96	2·98	17·761	
,,		116	6·96	3·48	24·221	
,,		117	5·96	2·98	17·761	
,,		130	1·28	8·64	11·059	
,,		131	0·20	13·3	2·660	
,,		132	1·66	13·99	23·223	
,,		133	0·70	13·64	9·548	
			30)71·31		651·309	9·13
			2·38			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
4th		63	3·95	14·995	58·480	
,,		64	2·08	15·16	31·532	
,,	Feb.,	67	0·75	17·505	13·287	
,,		68	0·41	17·595	7·213	
,,		80	1·91	13·075	24·973	
,,		82	1·33	14·535	19·331	
,,		83	0·08	14·51	11·608	
,,		85	0·30	18·45	5·535	
,,		86	0·99	17·305	17·331	
,,		95	3·84	13·47	51·590	
,,		96	3·83	11·705	18·942	
,,		97	1·75	10·825	36·972	
,,		98	1·33	11·205	14·902	
,,		99	2·34	15·8	38·972	
,,		101	1·93	6·685	12·902	
,,		112	0·83	9·365	7·772	
,,		113	1·87	8·935	16·864	
,,		114	4·17	10·285	42·888	
,,		115	1·58	6·75	10·665	
,,		116	0·58	7·25	4·205	
,,		117	1·08	6.5	7·020	
,,		131	1·92	14·36	27·571	
,,		132	4·00	16·82	67·28	
,,		133	4·83	16·405	79·236	
,,		148	10·43	5·215	54·392	
,,		198	10·01	5·005	50·100	
,,		207	10·85	5·425	58·861	
			27)78·97		790·424	10·09
			2·92			
,,		49	1·67	15·785	26·360	
,,		50	1·25	15·325	19·156	
,,		63	1·42	17·68	25·105	
,,		64	0·88	16·64	14·643	
,,		65	0·94	16·15	15·181	
,,		66	1·42	15·91	22·592	
,,		67	0·65	18·205	11·833	
,,		68	0·69	18·145	12·520	
,,		69	0·52	18·27	9·500	
,,		83	1·74	15·42	26·830	
,,		85	1·60	19·40	31·040	
,,		97	0·17	11·785	2·003	
,,		98	0·58	12·16	7·052	
,,		99	1·92	17·93	34·425	
,,		100	2·02	12·52	25·290	
,,		101	4·22	9·76	41·187	
,,		112	3·84	11·7	44·928	
,,		113	4·94	12·34	60·959	
,,		114	0·66	12·7	8·162	
,,		115	6·57	10·825	71·120	
,,		116	8·09	11·584	93·714	
,,		117	4·82	9·45	45·549	
,,		130	2·75	10·65	29·301	
,,		131	2·31	17·475	40·367	

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
4th		132	2·18	19·91	43·403	
,,		133	2·18	19·91	43·403	
,,		148	6·22	13·54	84·218	
,,		182	12·51	6·255	78·250	
,,		191	12·55	6·275	78·751	
,,		198	2·34	11·18	26·161	
,,		207	1·50	11·6	17·40	
			31)95·15		1091·403	11·47
			3·07			
,,		49	1·69	17·465	29·516	
,,		50	1·78	16·94	30·753	
,,		63	1·06	18·92	20·055	
,,		64	2·48	18·32	45·433	
,,		65	0·52	16·88	8·778	
,,		66	0·40	18·82	0·753	
,,		67	0·24	18·65	3·676	
,,		68	0·20	18·59	3·718	
,,		69	1·20	19·13	27·956	
,,		85	0·11	20·255	2·228	
,,		86	1·18	18·39	21·700	
,,		95	0·69	16·735	11·547	
,,		99	0·21	18·995	3·989	
,,		100	1·28	14·17	18·138	
,,		101	2·27	13·005	29·523	
,,		113	1·23	15·405	18·948	
,,		114	1·41	13·735	19·366	
,,		115	1·61	14·915	24·013	
,,		116	1·23	16·245	19·981	
,,		118	2·48	19·46	48·260	
,,		130	1·98	13·52	26·769	
,,		131	0·45	17·875	8·043	
,,		148	4·34	18·82	81·678	
,,		198	7·46	16·08	119·956	
,,		207	6·29	15·495	97·463	
,,		230	14·03	7·015	98·420	
,,		239	14·03	7·015	98·420	
			27)71·85		918·480	12·78
			2·66			
,,		118	0·30	20·85	6·255	
,,		182	8·75	16·885	147·744	
,,		191	8·71	16·905	147·242	
,,		198	1·33	20·475	27·232	
,,		207	2·50	19·89	49·725	
,,		230	7·37	17·715	130·560	
,,		239	7·37	17·715	130·560	
,,		246	14·86	7·43	110·410	
,,		255	15·40	7·70	118·580	
			9)66·59		868·308	13·40
			7·40			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block	Product.	Mean depth at which sinking was performed struck on whole class.
4th	June 1849.	80	0·16	14·11	2·258	
,,		82	0·25	15·325	3·831	
,,		96	0·08	13·66	1·093	
,,		100	0·74	15·18	11·233	
,,		101	0·61	14·445	8·811	
,,		246	6·41	18·165	116·437	
,,		255	5·87	18·335	107·626	
			7)14·12		251·289	17·79
			2·02			
,,	July 1849.	80	1·96	15·17	29·733	
,,		81	1·60	16·38	26·208	
,,		82	0·87	15·885	13·820	
,,		96	1·28	14·34	18·355	
,,		100	5·62	15·761	88·577	
,,		101	1·60	15·55	24·880	
,,		112	0·78	13·91	10·850	
,,		130	1·80	15·41	27·738	
			8)15·51		240·161	15·48
			1·94			
,,	August 1849.	80	1·04	16·67	17·337	
,,		81	2·16	18·36	39·658	
,,		82	0·88	16·76	14·749	
,,		96	0·76	15·36	11·674	
,,		100	0·71	21·475	15·247	
,,		101	1·19	16·945	20·164	
,,		112	1·67	15·235	25·442	
,,		113	0·03	16·035	0·481	
,,		130	2·01	17·315	34·803	
			9)10·45		179·555	17·18
			1·16			
,,	September 1849.	80	2·37	18·375	43·549	
,,		81	1·86	20·37	37·888	
,,		82	3·86	19·13	73·842	
,,		96	0·16	15·82	2·531	
,,		101	2·50	18·79	46·975	
,,		112	4·76	18·45	87·822	
,,		113	2·30	17·2	39·560	
,,		115	3·00	17·22	51·660	
,,		130	2·50	19·57	48·925	
			9)23·31		432·752	18·56
			2·59			
,,	October 1849.	80	2·20	20·66	45·452	
,,		82	0·94	21·53	20·238	
,,		96	0·18	15·99	2·878	
,,		101	1·48	20·76	30·754	
,,		113	1·65	19·175	31·639	
,,		115	2·44	19·95	48·654	
,,		130	1·18	21·41	25·264	
			7)10·07		204·879	20·34
			1·44			
4th	Novr. 1849.	147	11·05	5·52		5·52
,,		147	6·56	14·33	94·005	
,,		149	12·93	6·465	83·592	
,,		150	13·09	6·545	85·675	
,,	December 1849.	163	12·38	6·19	76·632	
,,		164	12·67	6·335	80·264	
,,		165	12·84	6·42	82·433	
,,		166	13·05	6·525	85·151	
,,		179	12·63	6·315	79·758	
,,		180	13·01	6·505	84·630	
			9)109·16		752·140	6·89
			12·13			
,,	January 1850.	147	4·85	20·035	97·170	
,,		149	7·68	16·77	128·793	
,,		150	9·35	17·765	166·103	
,,		163	8·23	16·495	135·754	
,,		164	8·64	16·99	146·793	
,,		165	9·60	17·64	169·344	
,,		166	9·39	17·745	166·625	
,,		179	8·68	16·97	147·300	
,,		180	9·43	17·775	167·618	
			9)75·85		1,325·500	17·48
			8·43			
,,	February 1850.	149	1·83	21·525	39·391	
,,		163	1·83	21·525	39·391	
,,		164	1·02	21·82	22·256	
,,		179	1·83	21·525	39·391	
			4)6·51		140·429	21·57
			1·63			
,,	April 1850.	127	12·71	Mean depth is half of total depth.	80·772	
,,		128	11·30		63·845	
,,		129	11.66		67·978	
,,		143	11·94		71·282	
,,		144	10·64		56·605	
,,		145	9·81		48·118	
,,		146	10·53		55·440	
,,		159	12·12		73·448	
,,		160	11·30		63·845	
,,		161	11·10		61·605	
,,		162	11·02		60·720	
,,		176	10·39		53·976	
,,		177	11·04		60·941	
,,		178	10·41		54·184	
,,		192	11·73		68·796	

Mean depth is half of total depth.

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
4th	April 1850.	193	11·81		69·738	
,,		194	10·47		54·810	
,,		208	10·85		58·861	
,,		209	11·58		67·048	
,,		210	11·60		67·280	
,,		224	10·51		55·230	
,,		225	10·68		57·031	
,,		226	11·71		68·562	
,,		240	10·08		50·803	
,,		241	10·47		54·810	
,,		242	9·68		46·851	
,,		256	10·04		50·401	
,,		257	10·43		54·392	
,,		258	9·93		49·302	
,,		271	8·77		38·456	
,,		272	9·58		45·888	
		31	335·89		1,831·018	5·45
			10·84			
,,	May 1850.	127	3·63	14·525	52·726	
,,		128	1·82	12·21	22·223	
,,		129	0·26	11·79	3·065	
,,		144	2·23	11·755	26·214	
,,		145	1·15	10·385	11·943	
,,		146	3·26	10·693	34·859	
,,		159	3·98	13·93	55·441	
,,		160	2·82	12·71	35·842	
,,		161	3·35	12·775	42·796	
,,		162	3·35	12·695	42·528	
,,		175	1·13	12·685	14·334	
,,		176	3·31	12·045	39·869	
,,		177	3·26	12·67	41·304	
,,		178	3·13	11·975	37·482	
,,		192	1·39	12·425	17·271	
,,		193	1·94	12·88	24·987	
,,		194	2·73	11·835	32·310	
,,		208	1·94	11·82	22·930	
,,		209	1·17	12·165	14·233	
,,		210	1·03	12·115	12·115	
,,		224	3·03	12·025	36·435	
,,		225	3·11	12·235	38·051	
,,		226	1·16	12·29	14·186	
,,		240	3·00	11·58	34·740	
,,		241	2·45	11·695	27·653	
,,		242	3·28	11·32	37·129	
,,		256	1·58	10·83	17·111	
,,		257	1·11	10·985	12·193	
,,		258	2·82	11·34	31·979	
,,		271	2·77	10·155	28·129	
,,		272	1·88	10·52	19·777	
		31	73·07		881·855	12·07
			2·36			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
4th	June 1850.	127	2·23	17·455	38·925	
,,		128	3·90	15·07	58·773	
,,		129	4·84	14·34	69·406	
,,		144	2·88	14·31	41·213	
,,		146	4·94	16·26	80·324	
,,		159	2·48	17·16	42·557	
,,		160	3·74	15·99	59·803	
,,		161	4·67	16·785	78·386	
,,		162	4·75	16·745	79·539	
,,		175	5·32	15·91	84·641	
,,		176	4·11	15·755	64·753	
,,		177	4·82	16·71	80·543	
,,		178	5·06	16·17	81·314	
,,		181	12·00	6·00	72·000	
,,		192	5·30	15·77	83·581	
,,		193	5·37	16·435	88·256	
,,		194	5·47	15·935	87·164	
,,		195	11·17	5·585	62·384	
,,		196	12·17	6·085	74·054	
,,		197	15·13	7·565	114·458	
,,		208	2·53	14·055	35·559	
,,		209	5·33	15·415	82·162	
,,		210	5·35	15·305	81·882	
,,		211	15·63	7·815	122·148	
,,		212	16·46	8·23	135·466	
,,		213	18·21	9·105	165·802	
,,		224	4·86	15·97	77·614	
,,		225	5·07	16·325	82·768	
,,		226	5·03	15·385	77·386	
,,		227	17·09	8·545	146·034	
,,		228	16·92	8·46	143·143	
,,		229	16·46	8·23	135·466	
,,		240	5·52	15·84	87·437	
,,		241	5·68	15·76	89·517	
,,		242	5·02	15·47	77·659	
,,		243	17·75	8·875	157·531	
,,		244	18·88	9·44	178·227	
,,		245	18·46	9·23	170·386	
,,		256	6·49	14·865	96·474	
,,		257	6·44	14·76	95·054	
,,		258	5·42	15·46	83·793	
,,		259	18·34	9·17	168·178	
,,		260	18·63	9·315	173·538	
,,		271	6·40	14·74	94·336	
,,		272	4·19	13·555	56·795	
		45	386·51		4,256·428	11·03
			8·59			

Class.	Date.	Number of block.	Depth sunk during month.	Arithmetical mean depth at which sinking was performed on each block.	Product.	Mean depth at which sinking was performed struck on whole class.
4th	July 1850.	195	6·08	14·21	56·397	
,,		196	5·62	14·98	84·187	
,,		197	3·54	16·90	59·826	
,,		211	2·87	17·065	48·976	
,,		212	2·37	17·645	41·819	
,,		213	1·29	18·855	24·323	
,,		227	1·99	18·085	35·989	
,,		228	2·58	18·21	46·982	
,,		229	3·04	17·98	54·659	
,,	July 1850.	243	1·75	18·625	32·594	
,,		244	0·28	19·02	5·325	
,,		245	1·04	19·00	19·760	
,,		259	1·16	18·92	21·947	
,,		260	0·87	19·065	16·587	
,,		181	6·00	15·000	90·000	
			15)40·48		669·371	16·53
			2·69			

A. G. GOODWYN, *Lieutenant,*

Exec. Engr, Nn. Dn. Ganges Canal.

Tabular Statement of the Cost of Undersinking Foundation Blocks of the Solani Aqueduct from 1st April 1848, to 1st November 1850.

Date of Sinking.	Class of Blocks.	Detail of Blocks worked at, as numbered in plan of Aqueduct Foundations.	Mean superficial area embraced by circumferences of bases of Blocks.	Arithmetical mean depth at which sinking was performed.	Mean monthly progress.	Cost of Undersinking. Labour.			Materials.			Tools and Sundries.			Total.			Removing Sand from Blocks. Labour.			Tools and Sundries.			Total.			Grand Total expense of entire operation.			Rate per running foot, on whole class, for mean depth at which sinking was performed.			Rate per sq. ft. of area as detailed in 4th, column, undersunk mean monthly progress of blocks, at mean depth noted in 5th column.			Rate per sq. ft. of area, as detailed in 4th column, undersunk one foot, at mean depth noted in 5th column.
			sq. feet.	feet.	feet.	RS.	A.	P.	RS.	A.	P.	RS.	A.	P.	RS.	A.	P.	RS.	A.	P.	RS.	A.	P.	RS.	A.	P.	RS.	A.	P.	RS.	A.	P.	RS.	A.	P.	ANNAS.
April 1848.	1st	Nos. 22, 23, 261* to 263,* and 268 to 270, ...	524·15	7·12	4·51	151	5	4	17	8	11	34	7	7	203	5	10	153	14	11	7	4	4	161	3	3	364	9	1	10	1	9	,,	1	5	·3141
May ,,	,,	Nos. 23, and 261 to 270, ...	554·02	15·95	7·25	935	14	11	153	2	0	34	7	8	1,123	8	7	691	12	4	7	4	5	699	0	9	1,822	9	4	22	13	6	,,	4	9	·6552
June ,,	,,	Nos. 15 to 22, and 261 to 269, ...	568·77	14·06	2·95	623	6	6	93	3	2	34	7	7	751	1	3	351	5	11	7	4	4	358	10	3	1,109	11	6	23	14	0	,,	1	10	·6214
July ,,	,,	Nos. 14 to 23, ...	570·51	16·14	4·79	378	4	8	54	4	10	34	7	7	467	1	1	257	7	10	7	4	4	264	12	2	731	13	3	15	4	6	,,	2	1	·4245
August ,,	,,	Nos. 14 and 16 to 23, ...	546·04	17·03	3·14	405	11	11	86	12	0	15	11	2	508	3	1	236	8	4	7	1	5	243	9	9	751	12	10	26	9	2	,,	2	5	·7696
September ,,	,,	Nos. 14 and 17 to 23, ...	544·23	20·36	1·80	318	1	0	67	10	1	15	11	2	401	6	3	167	9	1	7	1	4	174	10	5	576	0	8	40	6	0	,,	2	2	1·2037
October ,,	,,	No. 14, ...	500·00	20·72	2·27	34	1	1	3	1	9	15	11	2	52	14	0	16	0	0	7	1	4	23	1	4	75	15	4	33	7	4	,,	2	5	1·0646
April 1848.	2nd	Nos. 7, 30, 31, 103, 104, 106 to 110, 279, 280, 292 & 293,	385·88	8·95	7·62	417	10	1	45	7	10	43	2	10	506	4	9	371	3	9	10	4	11	381	8	8	887	13	5	8	5	2	,,	2	7	·3390
May ,,	,,	Nos. 30, 31, 103 to 110, 215 to 222, 279, 280, 292 & 293,	421·13	9·36	6·72	784	9	9	158	11	8	43	2	10	986	8	3	771	1	7	10	5	0	781	6	7	1,767	14	10	11	15	4	,,	3	1	·4585
June ,,	,,	Nos. 103 to 110, 215 to 222, 279, 280, 292 and 293,	433·24	17·95	5·05	1,093	9	1	155	6	6	43	2	11	1,292	2	6	714	12	3	10	4	11	725	1	2	2,017	3	8	19	15	3	,,	3	9	·7426
July ,,	,,	Nos. 30, 31, 103, and 105 to 110, ...	401·70	18·30	1·67	308	13	11	47	9	10	43	2	10	399	10	7	204	9	9	10	4	11	214	14	8	614	9	3	40	14	8	,,	2	9	1·6431
August ,,	,,	Nos. 30 and 31, ...	360·00	18·96	3·48	116	4	1	13	0	9	10	3	9	139	8	7	70	0	6	5	4	7	75	5	1	214	13	8	30	13	2	,,	4	9	1·3649
September ,,	,,	Nos. 30, 31, and 87 to 94, ...	437·38	5·27	7·49	294	1	7	45	0	3	10	3	9	349	5	7	165	13	3	5	4	8	171	1	11	520	7	6	6	15	2	,,	1	11	·2559
October ,,	,,	Nos. 90 to 94, ...	440·00	9·42	3·22	116	12	11	12	11	0	10	3	10	139	11	9	74	0	0	5	4	7	79	4	7	219	0	4	13	9	8	,,	1	7	·4917
November ,,	,,	Nos. 87 to 90, ...	440·00	12·36	2·32	45	2	6	3	13	5	9	0	1	58	0	0	31	10	3	3	14	11	35	9	2	93	9	2	10	1	2	,,	,,	10	·3592
December ,,	,,	Nos. 87 to 92, ...	440·00	15·14	5·16	248	12	8	43	6	7	9	0	1	301	3	4	201	4	1	3	15	0	205	3	1	506	6	5	16	5	7	,,	3	1	·5975
Jany. 1849.	,,	Nos. 87 to 94, ...	440·00	16·27	2·81	302	1	4	140	9	2	9	0	2	451	10	8	234	6	10	3	15	0	238	5	10	690	0	6	30	11	7	,,	3	2	1·1269
February ,,	,,	Nos. 87, 90, to 94, and 199 to 206, ...	440·00	6·39	6·35	462	10	7	216	13	8	8	12	5	688	4	8	361	0	7	7	7	0	368	7	7	1,056	12	3	11	14	0	,,	2	9	·4331
March ,,	,,	Nos. 91 to 93, 183 to 190, and 199 to 206, ...	440·00	7·09	6·22	468	12	10	167	13	4	8	12	4	645	6	6	678	13	5	7	7	0	686	4	5	1,331	10	11	11	4	3	,,	2	5	·3885
April ,,	,,	Nos. 126, 183, 185, 199 to 206, and 231 to 238, ..	440·00	9·93	8·97	942	4	5	229	12	5	33	3	10	1,205	4	8	930	10	8	21	2	2	951	12	10	2,157	1	6	12	10	5	,,	4	2	·4645
May ,,	,,	Nos. 126, 183 to 190, 199 to 206, 231 to 238, & 247 to 254,	440·00	13·00	7·78	1,529	7	10	489	1	7	33	3	11	2,051	13	4	1,346	8	11	21	2	2	1,367	11	1	3,419	8	5	13	5	3	,,	3	9	·4820
June ,,	,,	Nos. 126, 188 to 190, 233, and 247 to 254, ...	440·00	17·88	4·67	574	7	6	147	5	3	33	3	9	755	0	6	259	0	6	21	2	2	280	2	8	1,036	3	2	17	0	9	,,	2	11	·6245
April 1848.	3rd	Nos. 25, 27, 29, 273, 275, 277, 287, 289, and 291, ..	336·00	6·50	10·57	286	8	0	19	5	3	9	6	9	315	4	0	241	8	5	3	5	10	244	14	3	561	2	3	5	14	5	,,	3	0	·2838
May ,,	,,	Nos. 25, 27, 29, 273, 275, 277, 287, 289, and 291, ..	336·00	15·28	5·00	341	12	10	30	15	8	9	6	9	382	3	3	233	11	10	3	5	9	237	1	7	619	4	10	13	12	1	,,	3	3	·6500
June ,,	,,	Nos. 12, 273, 275, 277, 287, and 291, ...	336·00	19·58	3·44	251	15	6	44	9	4	9	6	9	305	15	7	137	13	5	3	5	9	141	3	2	447	2	9	21	10	10	,,	3	6	·0174
July ,,	,,	Nos. 12, 25, 27, and 29, ...	336·00	16·59	5·65	94	14	10	10	15	11	9	6	8	115	5	5	58	14	10	3	5	9	62	4	7	177	10	0	7	13	10	,,	2	1	·3687
August ,,	,,	Nos. 25, 27, and 29, ...	336·00	19·28	4·03	146	5	9	13	11	4	8	4	0	168	5	1	91	12	5	4	11	5	96	7	10	264	12	11	21	14	5	,,	4	2	1·0323
April 1848.	4th	Nos. 9, 24, 26, 28, 70, 102, 111, 274, 276, 278, 286, 288 and 290, ...	184·61	8·14	6·58	192	9	1	13	6	2	12	2	4	218	1	7	209	14	11	4	12	5	214	11	4	432	12	11	5	1	0	,,	2	11	·4432
May ,,	,,	Nos. 24, 26, 28, 70, 102, 111, 214, 223, 274, 276, 278, 286, 288 and 290, ...	174·96	11·36	4·79	279	7	3	30	2	0	12	2	4	321	11	7	245	3	1	4	12	6	249	15	7	571	11	2	8	8	5	,,	3	9	·7829
June ,,	,,	Nos. 11, 13, 102, 111, 214, 223, 274, 276, 278, 286, 288 and 290, ...	179·79	18·04	4·92	481	12	10	55	1	6	12	2	5	549	0	9	290	3	8	4	12	6	295	0	2	844	,,	11	14	4	6	,,	6	6	1·3211
July ,,	,,	Nos. 11, 13, 24, 26, 28, 37, 38, 51 to 54, 63, 67, 68, 79, 102 and 111, ...	163·7	11·69	3·64	269	3	4	38	11	7	12	2	4	320	1	3	210	10	7	4	12	6	215	7	1	535	8	4	8	10	7	,,	3	1	·8471
August ,,	,,	Nos. 24, 26, 28, 37, 38, 51 to 54, 67 to 69, 83 to 85, 99 and 100, ...	124·73	5·93	5·71	278	8	8	44	0	8	18	13	1	341	6	5	201	9	2	12	13	10	214	7	0	555	13	5	5	11	8	,,	4	2	·7297
September ,,	,,	Nos. 24, 37, 38, 49, 51 to 54, 64 to 67, 80 to 83, 86, 95 to 99, 102, 112 to 114 and 130, ...	122·05	5·34	5·69	338	13	4	47	8	1	18	13	1	405	2	6	257	4	3	12	13	10	270	2	1	675	4	9	4	6	4	,,	3	3	·5715
October ,,	,,	Nos. 37, 49 to 54, 64 to 69, 80 to 82, 84 to 86, 95 to 100 and 102, ...	114·22	10·31	2·54	369	5	3	38	6	8	18	13	2	426	9	1	293	4	4	12	13	11	306	2	3	732	11	4	11	1	3	,,	3	11	1·5419
November ,,	,,	Nos. 37, 49 to 52, 54, 63, 65, 66, 68, 69, 81, 82, 85, 86, 99 and 100, ...	125·05	11·56	3·46	273	14	7	49	12	7	9	0	1	332	11	3	181	4	8	5	9	3	186	13	11	519	9	2	8	13	3	,,	3	11	1·132
December ,,	,,	Nos. 37, 49, 50, 65, 66, 69, 81, 83 to 86 and 99, ..	115·40	13·59	2·31	207	14	5	33	2	1	9	0	1	250	0	7	173	9	1	5	9	3	179	2	4	429	2	11	15	7	11	,,	4	11	2·1284
Jany. 1849.	,,	Nos. 37, 49, 50, 53, 64, 66 to 69, 80, 82 to 86, 95 to 99, 101, 112, 114 to 117 and 130 to 133, ..	114·13	9·13	2·38	375	7	2	140	10	10	9	0	2	525	2	2	314	6	7	5	9	3	319	15	10	845	2	0	11	12	11	,,	3	11	1·6456
February ,,	,,	Nos. 63, 64, 67, 68, 80, 82, 83, 85, 86, 95 to 99, 101, 112 to 117, 131 to 133, 148, 198 and 207, ..	138·74	10·09	2·92	476	4	6	95	14	10	8	4	3	580	7	7	377	14	10	6	4	6	384	3	4	964	10	11	12	3	5	,,	4	1	1·3984
March ,,	,,	Nos. 49, 50, 63 to 69, 83, 85, 97 to 101, 112 to 117, 130 to 133, 148, 182, 191, 198, and 207, ..	131·11	11·47	3·07	594	6	11	107	0	6	8	4	4	709	11	9	603	1	0	6	4	7	609	5	7	1,319	1	4	13	13	10	,,	5	2	1·6829
April ,,	,,	Nos. 49, 50, 63 to 69, 85, 86, 95, 99 to 101, 113 to 116, 118, 130, 131, 148, 198, 207, 230 and 239,	148·30	12·78	2·66	405	10	9	83	7	11	7	4	1	496	6	9	345	4	0	4	0	1	349	4	1	845	10	10	11	12	4	,,	3	5	1·2845
May ,,	,,	Nos. 118, 182, 191, 198, 207, 230, 239, 246 and 255,	160·00	13·40	7·40	210	3	6	80	9	10	7	4	1	298	1	5	145	15	3	4	0	0	149	15	3	448	0	8	6	11	8	,,	5	0	·6757
June ,,	,,	Nos. 80, 82, 96, 100, 101, 246 and 255, ...	153·30	17·79	2·02	239	14	8	80	15	7	7	4	1	228	2	4	68	1	7	4	0	0	72	1	7	300	3	11	21	4	3	,,	5	5	2·6815
July ,,	,,	Nos. 80 to 82, 96, 100, 101, 112 and 130, ...	107·43	15·48	1·94	151	14	0	74	12	1	7	4	1	233	14	2	95	1	7	4	0	0	99	1	7	332	15	9	21	7	6	,,	6	2	3·1756
August ,,	,,	Nos. 80 to 82, 96, 100, 101, 112, 113 and 130, ..	112·50	17·18	1·16	154	13	7	100	11	6	3	0	1	258	9	2	139	9	6	3	0	3	142	9	9	401	2	11	38	7	3	,,	6	4	5·4597
September ,,	,,	Nos. 80 to 82, 96, 101, 112, 113, 115 and 130, ..	115·18	18·56	2·59	210	13	11	50	5	7	3	0	0	264	3	6	125	2	2	3	0	4	128	2	6	392	6	0	16	13	4	,,	6	1	2·3480
October ,,	,,	Nos. 80, 82, 96, 101, 113, 115 and 130, ...	115·58	20·34	1·44	101	1	2	47	13	8	3	0	0	151	14	10	66	12	2	3	0	4	69	12	6	221	11	4	22	0	3	,,	4	5	3·0668
November ,,	,,	No. 147, ...	220·00	5·52	11·05	15	4	10	12	8	2	5	3	3	33	0	3	57	9	7	5	9	6	63	3	1	96	3	4	8	11	4	,,	7	0	·6335
December ,,	,,	Nos. 147, 149, 150, 163 to 166, 179 and 180, ..	193·99	6·89	12·13	155	10	11	68	15	7	5	3	3	229	13	9	158	7	4	5	9	7	164	0	11	393	14	8	3	9	9	,,	3	7	·2946
Jany. 1850.	,,	Nos. 147, 149, 150, 163 to 166, 179 and 180, ..	193·38	17·48	8·43	203	10	4	90	3	3	5	3	3	299	0	10	363	12	11	5	9	7	369	6	6	668	7	4	8	13	0	,,	6	2	·7315
February ,,	,,	Nos. 149, 163, 164 and 179, ...	212·24	21·57	1·63	50	1	1	15	11	10	13	2	0	78	14	11	117	13	5	17	0	7	134	14	0	213	12	11	32	13	6	,,	4	0	2·4539
April ,,	,,	Nos. 127 to 129, 143 to 146, 159 to 162, 176 to 178, 192 to 194, 208 to 210, 224 to 226, 240 to 242, 256 to 258, 271 and 272, ...	200·40	5·45	10·84	672	7	5	206	14	9	13	2	1	892	8	3	1,086	6	8	17	0	8	1,103	7	4	1,995	15	7	5	15	1	,,	5	2	·4765
May ,,	,,	Nos. 127 to 129, 144 to 146, 159 to 162, 175 to 178, 192 to 194, 208 to 210, 224 to 226, 240 to 242, 256 to 258, 271 and 272, ...	202·52	12·07	2·36	352	6	0	213	10	7	71	8	7	637	9	2	585	1	6	28	13	11	613	15	5	1,251	8	7	17	2	1	,,	3	2	1·3381
June ,,	,,	Nos. 127 to 129, 144, 146, 159 to 162, 175 to 178, 181, 192 to 197, 208 to 213, 224 to 229, 240 to 245, 256 to 260, 271 and 272, ...	208·17	11·03	8·59	1,872	15	5	463	0	6	71	8	7	2,407	8	6	1,606	4	3	28	13	11	1,635	2	2	4,042	10	8	10	12	8	,,	7	1	·8246
July ,,	,,	Nos. 181, 195 to 197, 211 to 213, 227 to 229, 243 to 245, 259 and 260, ...	208·11	16·53	2·70	277	10	10	16	2	9	71	8	9	365	6	4	227	9	0	28	13	11	256	6	11	621	13	3	18	0	7	,,	3	2	1·1726

* Both 261 and 263 included. "To" bears this meaning throughout the column.

N. B. From 1st April to 1st November 1848, the pay of bildars was Rs. 4 per mensem; 4 bildars were employed working each jham and 3½ removing sand brought up by each jham. On 1st November 1848, the pay of bildars was reduced to Rs. 3-8. On 1st December 1848, the number of men working each jham was reduced to 3, with 3 men removing sand. The latter number was again reduced about 4 months later to 2½. This statement, however, as far as the removal of sand is concerned, must be received with caution, as, under particular circumstances, the number of men, thus employed, varied so considerably as to be beyond description in any general notice like the present.

Roorkee, 26th August 1851.

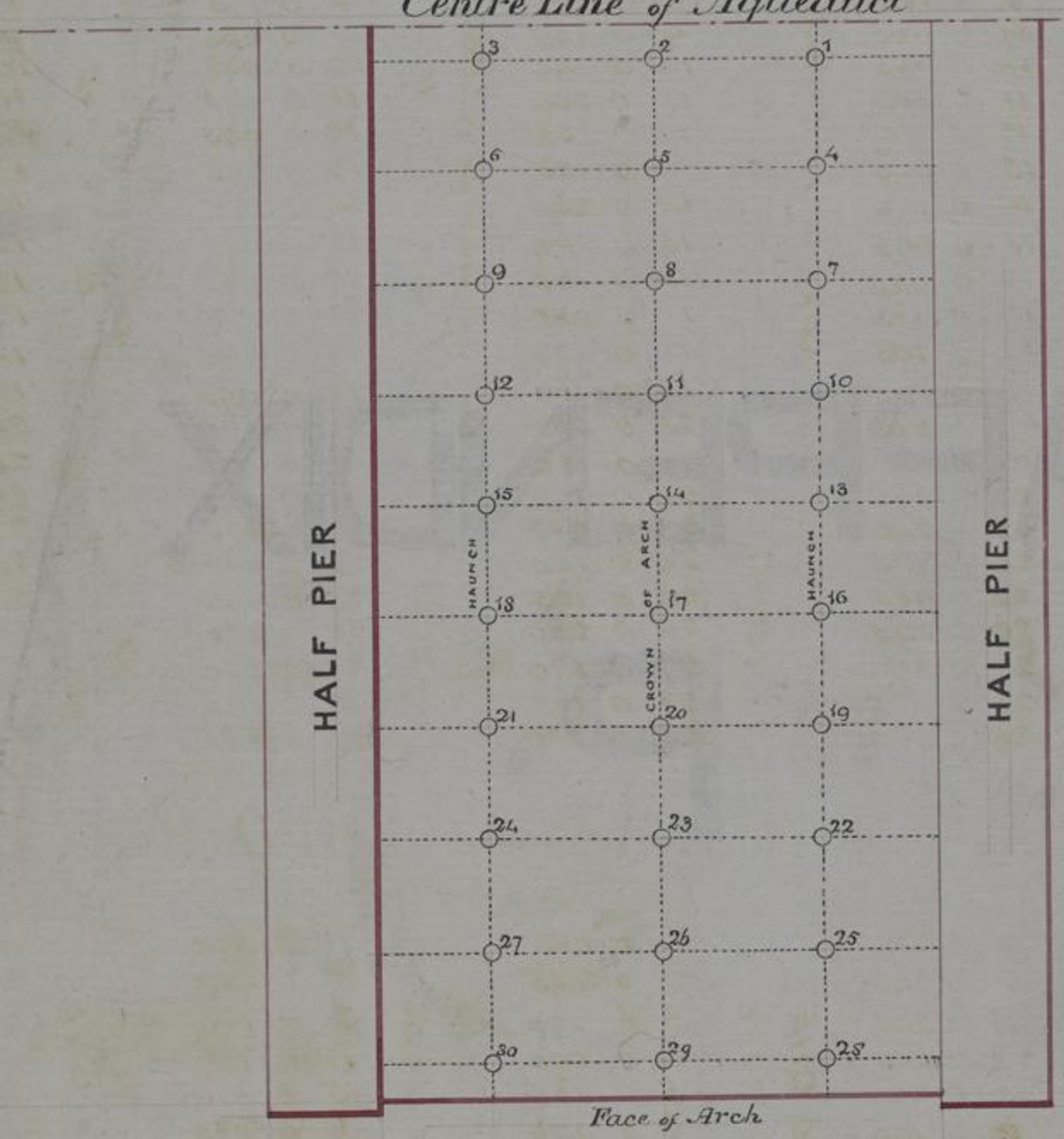
A. GOODWYN, Lieut.
Executive Engineer Northern Division Ganges Canal.

APPENDIX

P

PLAN

Shewing the points on the Haunches and Crown of the Solani Aqueduct Arches at which the Amount of Depression was measured -



Report of Sinking in the Arches of the Solani Aqueduct.

No 1 Arch			No 2 arch			No 3 Arch			No 4 arch			No 5 arch		
Level Points	Sinking	Average	Level Points	Sinking	Average	Level Points	Sinking	Average	Level Points	Sinking	Average	Level Points	Sinking	Average
1	0.095		1	0.115		1	0.145		1	0.090		1	0.140	
2	0.200		2	0.215		2	0.265		2	0.180		2	0.225	
3	0.110		3	0.115		3	0.160		3	0.085		3	0.105	
4	0.105		4	0.085		4	0.155		4	0.090		4	0.120	
5	0.175		5	0.195		5	0.270		5	0.180		5	0.190	
6	0.095		6	0.110		6	0.160		6	0.095		6	0.200	
7	0.005		7	0.095		7	0.145		7	0.095		7	0.115	
8	0.175		8	0.185		8	0.265		8	0.175		8	0.185	
9	0.095		9	0.005		9	0.150		9	0.095		9	0.085	
10	0.110		10	0.085		10	0.145		10	0.095		10	0.125	
11	0.175		11	0.185		11	0.250		11	0.175		11	0.175	
12	0.095		12	0.100		12	0.155		12	0.095		12	0.080	
13	0.110		13	0.090		13	0.155		13	0.095		13	0.115	
14	0.175		14	0.190		14	0.260		14	0.175		14	0.165	
15	0.095		15	0.095		15	0.160		15	0.095		15	0.080	
16	0.105		16	0.090		16	0.165		16	0.095		16	0.105	
17	0.185		17	0.185		17	0.280		17	0.175		17	0.180	
18	0.095		18	0.105		18	0.170		18	0.095		18	0.085	
19	0.110		19	0.105		19	0.165		19	0.095		19	0.110	
20	0.190		20	0.205		20	0.285		20	0.170		20	0.180	
21	0.095		21	0.115		21	0.180		21	0.095		21	0.095	
22	0.115		22	0.095		22	0.170		22	0.095		22	0.125	
23	0.200		23	0.200		23	0.285		23	0.175		23	0.200	
24	0.105		24	0.105		24	0.190		24	0.090		24	0.100	
25	0.120		25	0.085		25	0.165		25	0.095		25	0.120	
26	0.205		26	0.195		26	0.280		26	0.185		26	0.215	
27	0.100		27	0.110		27	0.170		27	0.090		27	0.110	
28	0.135		28	0.100		28	0.160		28	0.105		28	0.140	
29	0.225		29	0.185		29	0.270		29	0.195		29	0.235	
Inches - Average sinking of 20 Points		0.1005'	Inches - Average sinking of 20 Points		0.0935	Inches - Average sinking of 20 Points		0.1605	Inches - Average sinking of 20 Points		0.0933	Inches - Average sinking of 20 Points		0.1135
Crown		0.1905'	Crown		0.1940	Crown		0.2710	Crown		0.1785	Crown		0.1950

No 6 Arch			No 7 Arch			No 8 Arch			No 9 Arch			No 10 Arch		
1	0.165		1	0.235		1	0.085		1	0.090		1	0.079	
2	0.250		2	0.340		2	0.165		2	0.160		2	0.180	
3	0.140		3	0.205		3	0.090		3	0.080		3	0.105	
4	0.165		4	0.230		4	0.090		4	0.080		4	0.080	
5	0.235		5	0.320		5	0.165		5	0.140		5	0.180	
6	0.130		6	0.190		6	0.090		6	0.095		6	0.100	
7	0.160		7	0.230		7	0.085		7	0.090		7	0.078	
8	0.235		8	0.315		8	0.160		8	0.140		8	0.190	
9	0.130		9	0.200		9	0.095		9	0.090		9	0.100	
10	0.165		10	0.220		10	0.095		10	0.075		10	0.084	
11	0.240		11	0.315		11	0.160		11	0.135		11	0.180	
12	0.135		12	0.200		12	0.100		12	0.070		12	0.100	
13	0.160		13	0.225		13	0.090		13	0.090		13	0.065	
14	0.155		14	0.315		14	0.160		14	0.140		14	0.186	
15	0.105		15	0.190		15	0.100		15	0.090		15	0.060	
16	0.166		16	0.215		16	0.095		16	0.085		16	0.090	
17	0.255		17	0.310		17	0.155		17	0.135		17	0.190	
18	0.150		18	0.195		18	0.095		18	0.085		18	0.105	
19	0.160		19	0.225		19	0.095		19	0.075		19	0.089	
20	0.250		20	0.310		20	0.165		20	0.135		20	0.200	
21	0.150		21	0.195		21	0.095		21	0.085		21	0.100	
22	0.170		22	0.220		22	0.095		22	0.100		22	0.078	
23	0.260		23	0.320		23	0.160		23	0.145		23	0.190	
24	0.145		24	0.200		24	0.095		24	0.090		24	0.110	
25	0.190		25	0.220		25	0.105		25	0.090		25	0.078	
26	0.280		26	0.320		26	0.170		26	0.160		26	0.200	
27	0.160		27	0.210		27	0.105		27	0.090		27	0.110	
28	0.200		28	0.215		28	0.115		28	0.100		28	0.069	
29	0.315		29	0.315		29	0.190		29	0.175		29	0.200	
30	0.170		30	0.210		30	0.115		30	0.090		30	0.110	
Inches - Average sinking of 20 Points -		0.15552	Inches - Average sinking of 20 Points -		0.2115	Inches - Average sinking of 20 Points -		0.0965	Inches - Average sinking of 20 Points -		0.0870	Inches - Average sinking of 20 Points -		0.0895
Crown -		0.24755	Crown -		0.3180	Crown -		0.1650	Crown -		0.14455	Crown -		0.1895

Report of Sinking in the Arches of the Solani Aqueduct—

No 11 Arch			No 12 Arch			No 13 Arch			No 14 Arch			No 15 Arch		
Level Points	Sinking	Average	Level Points	Sinking	Average	Level Points	Sinking	Average	Level Points	Sinking	Average	Level Points	Sinking	Average
1	0·100		1	0·060		1	0·049		1	0·076		1	0·083	
2	0·192		2	0·120		2	0·129		2	0·142		2	0·153	
3	0·110		3	0·065		3	0·051		3	0·078		3	0·076	
4	0·100		4	0·065		4	0·050		4	0·076		4	0·082	
5	0·200		5	0·120		5	0·126		5	0·141		5	0·152	
6	0·190		6	0·070		6	0·052		6	0·079		6	0·085	
7	0·094		7	0·080		7	0·048		7	0·075		7	0·090	
8	0·190		8	0·130		8	0·132		8	0·143		8	0·154	
9	0·110		9	0·085		9	0·050		9	0·076		9	0·085	
10	0·105		10	0·080		10	0·049		10	0·077		10	0·090	
11	0·195		11	0·130		11	0·129		11	0·141		11	0·150	
12	0·100		12	0·080		12	0·057		12	0·075		12	0·182	
13	0·100		13	0·080		13	0·050		13	0·077		13	0·076	
14	0·195		14	0·120		14	0·125		14	0·141		14	0·156	
15	0·100		15	0·080		15	0·051		15	0·076		15	0·083	
16	0·120		16	0·070		16	0·057		16	0·077		16	0·083	
17	0·210		17	0·130		17	0·133		17	0·141		17	0·148	
18	0·100		18	0·080		18	0·050		18	0·076		18	0·076	
19	0·190		19	0·080		19	0·052		19	0·075		19	0·085	
20	0·220		20	0·140		20	0·128		20	0·142		20	0·158	
21	0·120		21	0·085		21	0·049		21	0·077		21	0·082	
22	0·110		22	0·080		22	0·049		22	0·076		22	0·085	
23	0·200		23	0·130		23	0·130		23	0·141		23	0·153	
24	0·105		24	0·080		24	0·050		24	0·075		24	0·090	
25	0·110		25	0·070		25	0·056		25	0·079		25	0·076	
26	0·195		26	0·130		26	0·132		26	0·141		26	0·152	
27	0·		27	0·075		27	0·050		27	0·076		27	0·082	
28	0·		28	0·080		28	0·057		28	0·078		28	0·083	
29	0·190		29	0·140		29	0·126		29	0·141		29	0·155	
30	0·094		30	0·080		30	0·050		30	0·076		30	0·076	
		Aunches - Average Sinking 0·1029			Aunches - Average Sinking 0·0760			Aunches - Average Sinking 0·0502			Aunches Average Sinking 0·0765			Aunches Average Sinking 0·0832
		Crown - do 0·1987			Crown do 0·1290			Crown do 0·1290			Crown do 0·1419			Crown do 0·1530

No 16 Arch			No 17 Arch			No 18 Arch			No 19 Arch			No 20 Arch		
1	0·150		1	0·080		1	0·140		1	0·033		1	0·045	
2	0·285		2	0·220		2	0·300		2	0·132		2	0·165	
3	0·150		3	0·110		3	0·170		3	0·034		3	0·065	
4	0·120		4	0·080		4	0·120		4	0·032		4	0·035	
5	0·210		5	0·210		5	0·260		5	0·132		5	0·150	
6	0·115		6	0·100		6	0·140		6	0·034		6	0·050	
7	0·105		7	0·090		7	0·110		7	0·035		7	0·030	
8	0·140		8	0·210		8	0·250		8	0·133		8	0·140	
9	0·090		9	0·100		9	0·120		9	0·033		9	0·045	
10	0·085		10	0·095		10	0·115		10	0·034		10	0·020	
11	0·170		11	0·195		11	0·230		11	0·132		11	0·130	
12	0·085		12	0·100		12	0·110		12	0·032		12	0·040	
13	0·080		13	0·085		13	0·110		13	0·033		13	0·020	
14	0·155		14	0·205		14	0·235		14	0·133		14	0·110	
15	0·080		15	0·090		15	0·120		15	0·032		15	0·040	
16	0·085		16	0·085		16	0·115		16	0·033		16	0·020	
17	0·150		17	0·195		17	0·230		17	0·132		17	0·120	
18	0·075		18	0·090		18	0·100		18	0·032		18	0·035	
19	0·090		19	0·090		19	0·110		19	0·032		19	0·000	
20	0·160		20	0·195		20	0·230		20	0·133		20	0·100	
21	0·075		21	0·080		21	0·100		21	0·034		21	0·015	
22	0·085		22	0·100		22	0·100		22	0·035		22	0·000	
23	0·175		23	0·180		23	0·210		23	0·133		23	0·090	
24	0·035		24	0·080		24	0·095		24	0·034		24	0·010	
25	0·090		25	0·100		25	0·095		25	0·032		25	0·020	
26	0·190		26	0·190		26	0·195		26	0·132		26	0·070	
27	0·075		27	0·070		27	0·070		27	0·034		27	0·000	
28	0·120		28	0·090		28	0·010		28	0·034		28	0·040	
29	0·240		29	0·175		29	0·195		29	0·133		29	0·060	
30	0·120		30	0·065		30	0·070		30	0·033		30	0·000	
		Aunches - Average Sinking 0·0990			Aunches Average Sinking 0·0880			Aunches Average Sinking 0·1060			Aunches - Average Sinking 0·0332			Aunches Average Sinking 0·0265
		Crown do 0·1875			Crown do 0·1975			Crown do 0·2335			Crown do 0·1325			Crown do 0·1135

Report of Sinking in the Arches of the Soldini Aqueduct.—

No 21 arch			No 22 arch			No 23 arch			No 24 arch			No 25 arch		
Levels Points	Sinking	Average	Levels Points	Sinking	Average	Levels Points	Sinking	Average	Levels Points	Sinking	Average	Levels Points	Sinking	Average
1	0·070		1	0·090		1	0·087		1	0·130		1	0·100	
2	0·180		2	0·210		2	0·152		2	0·200		2	0·140	
3	0·065		3	0·095		3	0·087		3	0·115		3	0·110	
4	0·050		4	0·060		4	0·088		4	0·120		4	0·090	
5	0·160		5	0·175		5	0·151		5	0·185		5	0·140	
6	0·040		6	0·080		6	0·090		6	0·105		6	0·090	
7	0·050		7	0·045		7	0·086		7	0·110		7	0·085	
8	0·140		8	0·130		8	0·150		8	0·165		8	0·130	
9	0·045		9	0·050		9	0·089		9	0·100		9	0·090	
10	0·040		10	0·030		10	0·087		10	0·110		10	0·070	
11	0·030		11	0·130		11	0·152		11	0·160		11	0·120	
12	0·030		12	0·045		12	0·086		12	0·090		12	0·065	
13	0·025		13	0·040		13	0·087		13	0·100		13	0·060	
14	0·110		14	0·125		14	0·149		14	0·145		14	0·110	
15	0·025		15	0·060		15	0·086		15	0·085		15	0·070	
16	0·020		16	0·030		16	0·086		16	0·090		16	0·050	
17	0·100		17	0·120		17	0·157		17	0·140		17	0·095	
18	0·020		18	0·040		18	0·087		18	0·070		18	0·055	
19	0·020		19	0·030		19	0·086		19	0·080		19	0·050	
20	0·095		20	0·115		20	0·149		20	0·145		20	0·090	
21	0·010		21	0·040		21	0·087		21	0·070		21	0·055	
22	0·015		22	0·030		22	0·089		22	0·070		22	0·050	
23	0·100		23	0·120		23	0·152		23	0·120		23	0·085	
24	0·010		24	0·040		24	0·086		24	0·070		24	0·040	
25	0·000		25	0·030		25	0·090		25	0·030		25	0·010	
26	0·085		26	0·120		26	0·157		26	0·110		26	0·080	
27	0·010		27	0·030		27	0·088		27	0·040		27	0·035	
28	0·000		28	0·010		28	0·087		28	0·050		28	0·030	
29	0·055		29	0·110		29	0·152		29	0·090		29	0·070	
30	0·000		30	0·040		30	0·087		30	0·040		30	0·035	
		Arches Sinking			Arches Sinking			Arches Sinking			Arches Sinking			Arches Sinking
		Average			Average			Average			Average			Average
		Crown			Crown			Crown			Crown			Crown

No 26 arch			No 27 arch			No 28 arch			No 29 arch			No 30 arch		
1	0·140		1	0·055		1	0·055		1	0·065		1	0·035	
2	0·240		2	0·133		2	0·145		2	0·125		2	0·125	
3	0·150		3	0·065		3	0·065		3	0·050		3	0·010	
4	0·140		4	0·064		4	0·075		4	0·068		4	0·045	
5	0·220		5	0·135		5	0·135		5	0·125		5	0·115	
6	0·150		6	0·064		6	0·065		6	0·040		6	0·020	
7	0·115		7	0·065		7	0·075		7	0·060		7	0·045	
8	0·195		8	0·132		8	0·145		8	0·130		8	0·125	
9	0·125		9	0·060		9	0·075		9	0·055		9	0·030	
10	0·110		10	0·070		10	0·090		10	0·070		10	0·055	
11	0·175		11	0·136		11	0·155		11	0·130		11	0·130	
12	0·120		12	0·053		12	0·075		12	0·040		12	0·035	
13	0·100		13	0·065		13	0·080		13	0·060		13	0·055	
14	0·175		14	0·134		14	0·160		14	0·135		14	0·125	
15	0·160		15	0·070		15	0·070		15	0·050		15	0·040	
16	0·090		16	0·060		16	0·085		16	0·060		16	0·065	
17	0·113		17	0·133		17	0·155		17	0·130		17	0·135	
18	0·110		18	0·063		18	0·085		18	0·050		18	0·040	
19	0·085		19	0·055		19	0·090		19	0·060		19	0·065	
20	0·160		20	0·135		20	0·165		20	0·135		20	0·130	
21	0·100		21	0·064		21	0·095		21	0·065		21	0·045	
22	0·085		22	0·065		22	0·090		22	0·060		22	0·065	
23	0·150		23	0·134		23	0·160		23	0·145		23	0·135	
24	0·090		24	0·064		24	0·100		24	0·060		24	0·055	
25	0·070		25	0·065		25	0·085		25	0·080		25	0·075	
26	0·140		26	0·133		26	0·160		26	0·135		26	0·140	
27	0·090		27	0·070		27	0·090		27	0·053		27	0·050	
28	0·075		28	0·065		28	0·095		28	0·090		28	0·075	
29	0·140		29	0·135		29	0·170		29	0·145		29	0·145	
30	0·080		30	0·048		30	0·110		30	0·065		30	0·065	
		Arches Sinking Average			Arches Sinking Average			Arches Sinking Average			Arches Sinking Average			Arches Sinking Average
		Crown			Crown			Crown			Crown			Crown

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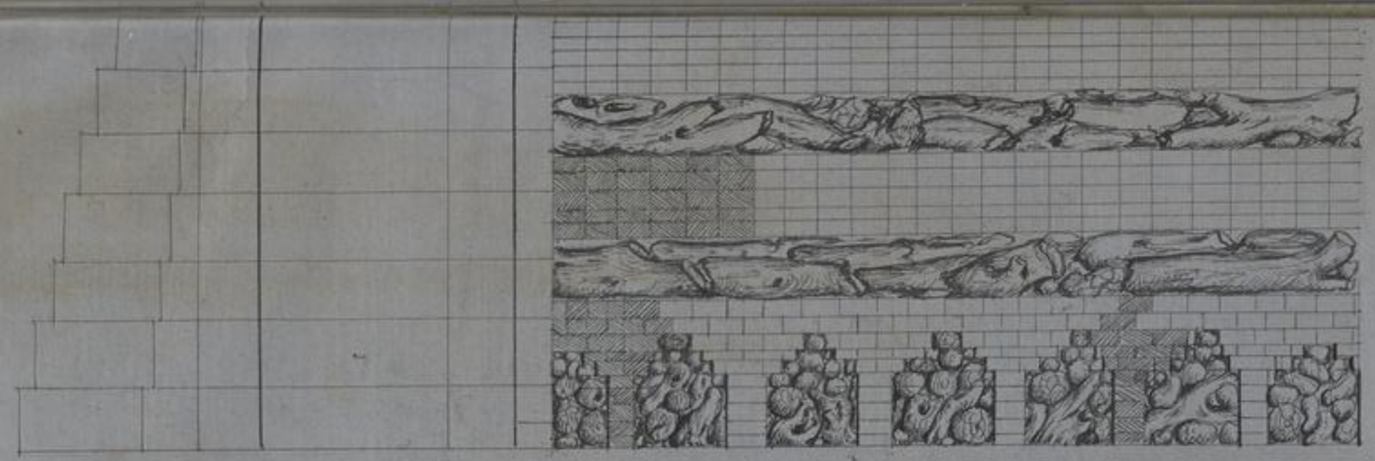
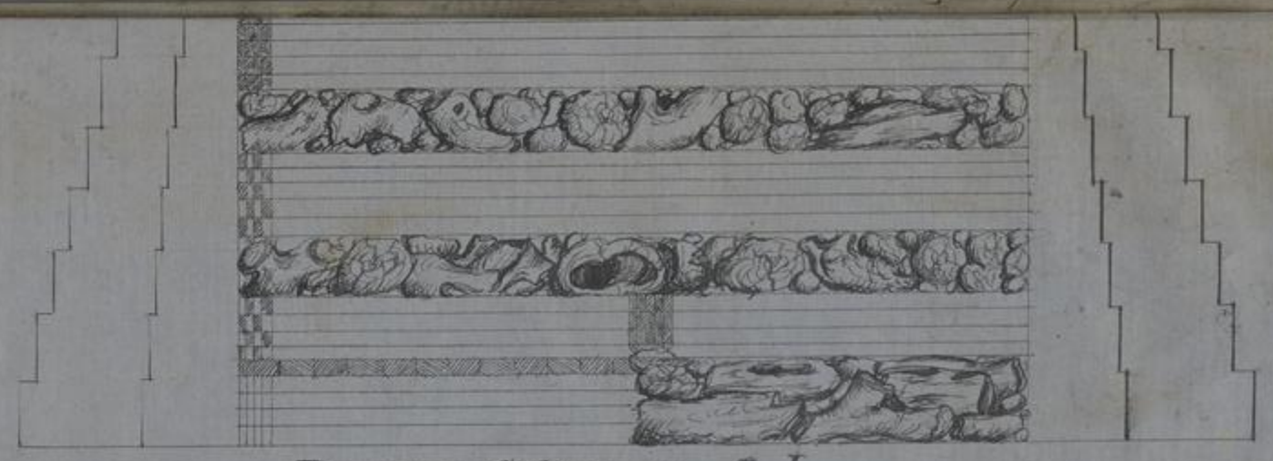
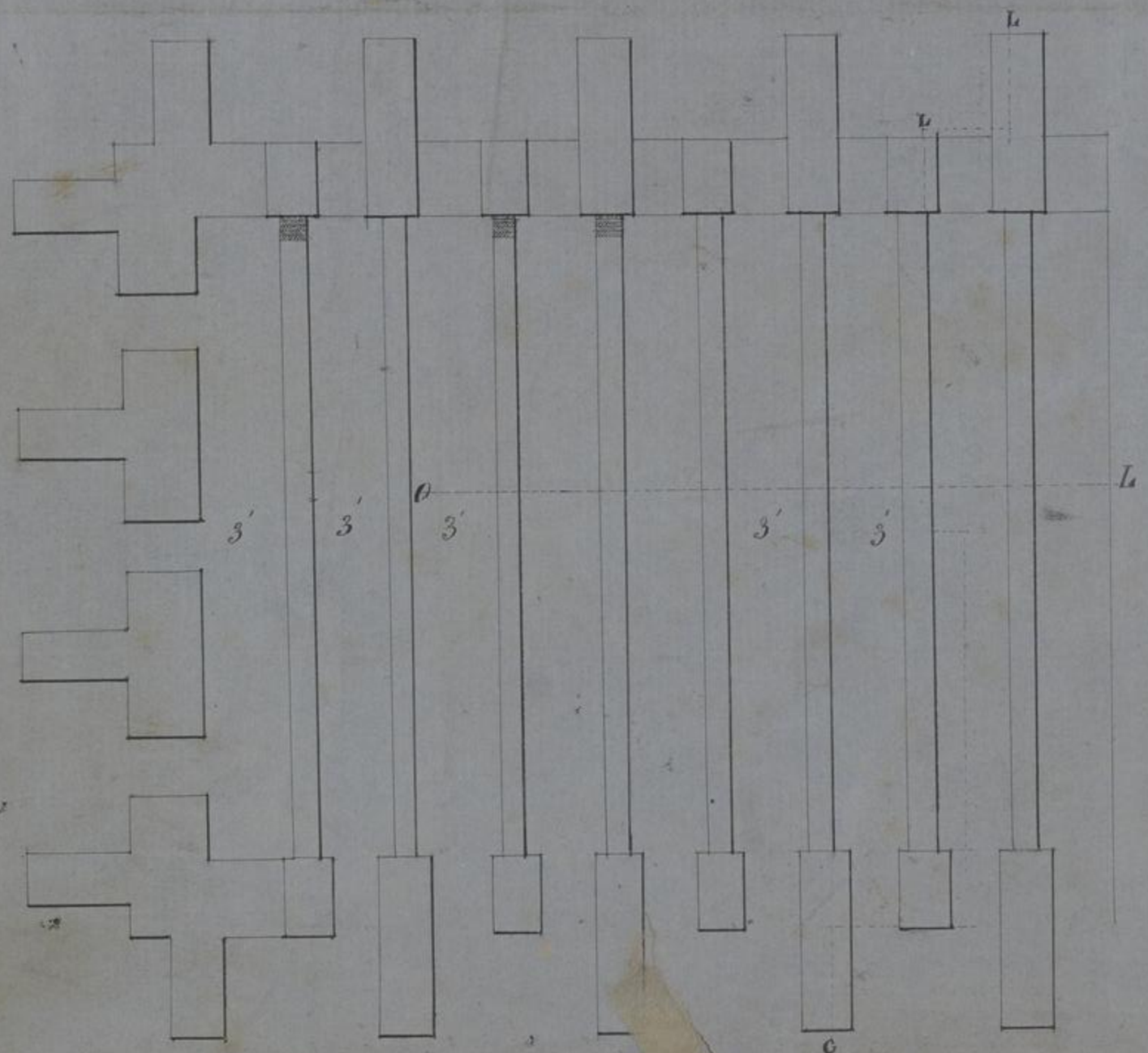


Section on the Line O L



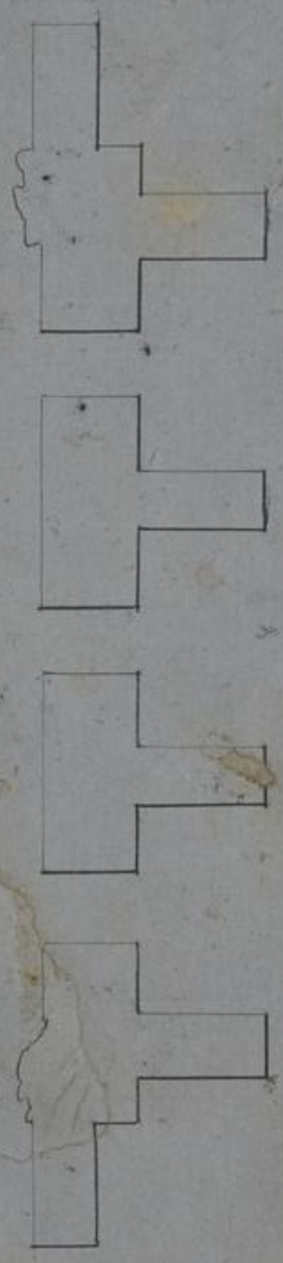
Transverse Section on C L



Dimension of Kiln

72′ × 40′ × 15

Scale of 7½ Feet to an Inch



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